UPDATED EDITION

Compendium

OF
SKILL SETS ON
AGRICULTURE AND ALLIED SCIENCES

Directorate of Instruction
CENTRAL AGRICULTURAL UNIVERSITY
IMPHAL-795004, MANIPUR

COMPENDIUM OF SKILL SETS ON AGRICULTURE AND ALLIED SCIENCES (Updated Edition)

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FOREWORD

India's educational system is undergoing unprecedented constructive change, paving the way for developing a competent and future-ready workforce in all fields including Agriculture and Allied Sciences. Riding on the advantage of the demographic dividend, our persistent focus on young minds has propelled the education sector to unprecedented heights in the past several years. Focusing on skill development as advocated by NEP-2020 guidelines will surely redefine India's position in the global talent scene. Linking our current curricula to Scale-Up and Scale-Out of the students is the need of the hour. Every institution must focus on developing skill sets in accordance with their course curriculum so that students may benefit and it may further be utilized to train interested stakeholders.

India being a leader in agricultural production requires a well-trained workforce that can ensure our nation remains at the pinnacle of agriculture-related developments globally. The agriculture sector holds a good scope for employment generation in the future. Proper knowledge of the skills in the field of Agriculture and Allied Sciences is very much essential for maintaining stability in the production of crop, animal, and aquaculture-based products.

India is aiming to be a job provider rather than a job seeker for future generations. To achieve this, sound knowledge of do-how along with related know-how of the technical details in various aspects of Agriculture and Allied Sciences is necessary, which will provide a bountiful opportunity for anyone to be an entrepreneur with minimum investment in different aspects of agricultural production right from farm to fork. Therefore, it is high time to give proper training to start skill development in the Agriculture and Allied sectors.

The ***"Compendium of Skill Sets on Agriculture and Allied Sciences"*** encompasses almost all the skills of these fields. I congratulate all the faculties of all the constituent colleges of Central Agricultural University, Imphal for their efforts in compiling these skill sets in the form of a very useful document

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PREFACE

The New Education Policy (2020) of India is a transformative step towards a change in the education system. It is a unique approach emphasizing digital literacy and skill development in Agriculture and Allied Sciences to play a pivotal role in human survival and economic growth. It is the sector of the economy which gives vast employment generation with huge returns. From the stage of seed sowing to the edible product on the table of the consumer, the skills and the techniques involved could improve income and livelihood for the entrepreneurs. The trend of small start-ups in the country has been increasing in the past few years encouraging the youths to a mass entrepreneurship rather than being a job seeker. With the initiative of digitalization by the Government of India, every nook and corner of the country is able to access with ease. Skill orientation in agriculture will generate job opportunities and enhance livelihood.

The ***"Compendium of Skill Sets on Agriculture and Allied Sciences"*** is an initiative taken up by the Central Agricultural University, Imphal for easy access the skills in all the disciplines of Agriculture and Allied Sciences to facilitate learning of the students/ young entrepreneurs/ youths/ farmers, etc. It comprises detailed information for starting any skill as per the course curricula recommended by ICAR for undergraduate courses in Agriculture and Allied Sciences. This is the First Edition of the Compendium to be upgraded from time to time as per the requirements and changes of the syllabus in the future. This Compendium is a compilation of the skills contributed by various faculty members of all the 13 constituent colleges of the University which is duly acknowledged.

We would like to express our immense gratitude to Dr. Anupam Mishra, Hon'ble Vice Chancellor, Central Agricultural University, Imphal for his valuable guidance and immense support and overall being the driving force in the preparation of this document.

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AGRICULTURE

AGRONOMY

Skill Set (Agron) 1: Land preparation of field crops

Skills to impart: To impart the art and techniques of land preparation to the students under different conditions.

Materials required:

Tractor, tillage machineries (disc harrow, rotavator, cultivators, leveler, power tiller etc., hand tools/implements (spade, garden fork, wooden planks, hand -hoe, long knife etc.)

Primary tillage

Procedure: Land preparation of crops may be done in two different ways, one for upland and the other for wet low land conditions (Rice):

A. Upland

Secondary tillage

a. Removing existing vegetation, rocks, and debris from the field and improving field hygiene.

b. Discing, harrowing/ploughing, and rotavating the field to incorporate stubbles and hasten decomposition.

c. Channelizing, bunding, and levelling of the field

d. The layout of the field is according to the desired plot size and designs.

e. Sowing the seed.

Puddling in rice field

B. Lowland:

a. Wet preparation is the most common way of preparing lowland fields. In this method, the soil is tilled in a saturated or flooded condition by tractors, rotavators, etc. to break the soil particles into smaller/finer particles.

Field levelling/planking

b. It helps in controlling weeds and facilitates incorporation of nutrients in the soil. With its nature, wet preparation has a high water requirement.

c. Wet preparation is suitable for crops like rice with access to irrigation and bunds that enable flooding.

d. It involves puddling the soil to develop a hard pan and reduce water loss in lowland rice fields.

e. Mud and water are thoroughly mixed and weeds are incorporated.

f. Weeds, rice straws, and stubble have been ploughed under the soil and are thoroughly decayed.

g. Land is leveled and kept ready for sowing or transplanting.

Skill Set (Agron) 2: Sowing of seeds

Materials required: Khurpi, furrow opener, dibbler and seed drill

Sowing

Sowing or seeding is the art of placing seeds in the soil to have good germination in the field. A perfect seeding gives the correct amount of seed per unit area, the correct depth at which seed is placed in the soil and correct spacing between row-to-row and plant plant-to-plant.

Sowing methods

1	Broadcasting	2.	Dibbling
3.	Drilling	4.	Seed dropping behind the plough
5.	Transplanting	6.	Hill dropping
7.	Check row planting		

Broadcasting

Broadcasting is otherwise called as random sowing. Scattering the seeds is done for many crops. Broadcasting is mostly followed for small-sized to medium-sized crops. This is the largest method of sowing followed in India, as it is the easiest and cheapest and requires minimum labours. To have an optimum plant population in a unit area, certain rules should be followed. Only a skilled person should broadcast the seeds for uniform scattering. The seeds are broadcasted in a narrow strip and the sowing is completed strip by strip. To ensure a good and uniform population, it is better to broadcast in either direction. This is called crisscross sowing. If the seed is too small, it is mixed with sand to make a bulky one for easy handling.

Dibbling

Dibbling is the process of placing seeds in holes made in seedbeds and covering them. In this method, seeds are placed in holes made at definite depths at fixed spacing. The equipment used for dibbling is called a dibbler. It is a conical instrument used to make proper holes in the field. Small hand dibblers are made with several conical projections made in a frame. This is a very time-consuming process, so it is not suitable for small seeds. Most vegetables are sown in this way. This is line sowing. The seeds are dibbled at 2/3rd from the top or 1/3rd at the bottom of the ridge.

Drilling or drill sowing

Drilling can be done by

a. Sowing behind the plough
b. Bullock drawn seed drills
c. Tractor-drawn seed drills

Seed dropping behind the plough

It is a very common method. It is used for seeds like maize, gram, peas, wheat, and barley. A man drops seeds in the furrow behind the

plough. Sowing behind the plough can be done with a device known as *malobonsa*. It consists of a bamboo tube provided with a funnel-shaped mouth. One man drops the seeds through the funnel and the other man handles the plough and the bullocks. This is a slow and laborious method.

Transplanting

Transplanting consists of preparing seedlings in a nursery and then planting those seedlings in the prepared field. It is commonly done for vegetables and flowers. It is very time-consuming operation. Equipment for placing plants in the soil is called transplanting.

Hill dropping

In this method, seeds are dropped at fixed spacing and not in a co tinuous stream. Thus, the spacing between plant to plant in a row is constant. In case of drills, the seeds are dropped in continuous stream and the spacing between plant to plant in a row is not constant.

Check row planting

It is a method of planting in which row to row and plant to plant distance is uniform. In this method, seeds are planted precisely along straight parallel furrows. The rows are always in two perpendicular directions. A machine used for check row planting is called check row planter.

Skill Set (Agron) 3: Nursery raising of rice crops

Seedling nurseries use 15 to 20% of the total farming area. In preparing the nursery seedbed, the surface needs to be level, free of weeds, and well-drained. Low rates of nitrogen and phosphate fertilizer can be applied to the nursery.

Different nursery systems

Wet bed nursery

There are 4 nursery systems for transplanting:

1. Wet-bed nursery
2. Dry-bed nursery
3. Dapog or mat nursery
4. Seedling boxes for mechanical transplanting

Wet-bed Nursery

- Compute the seed and seedbed area: 50 kg seed and 500 m^2 seedbed area for transplanting one hectare (ha) of the main field
- Start preparing the seedbed 2 weeks before planting time
- Add organic manures and/or fertilizers as needed
- Irrigate, plow, puddle, and level the field
- Prepare beds of 1 to 1.5 m width, 4-5 cm height, and any convenient length
- Pre-germinate the seeds 2 days before sowing: 24 hrs. soaking, and 24 hrs. incubation are required.
- Sow the pre-germinated seeds on beds
- Water the seedbed 2-3 days after sowing (DAS) and then maintain a water level of 2-5 cm, depending on the height of seedlings
- Apply 20-40 g urea or Diammonium Phosphate (DAP) per m^2 at 10 DAS, if needed

- Apply pesticide as and when needed
- Seedlings are ready for transplanting from 20-25 DAS
- Cover the nursery bed in a cold climate

Dry-bed Nursery

Dry bed nursery

- Compute the seed and seedbed area: 50 kg seed and 500 m^2 seedbed area for transplanting one ha of main field
- Locate the seedbed away from electric light in a fertile field with light soil and easy access to a water source
- Start preparing the seedbed 2 weeks before planting time
- Add enough organic manures and/or fertilizers
- Plow and harrow the field
- Prepare raised seedbeds of 1.5 m width, 0.1-0.15 m height, and any convenient length
- Seed priming: weigh required quantity of clean seed, soak for 24 hrs. and then dry in the shade
- Primed seed is reported to germinate faster than fresh dry seed
- Sow the primed seeds on raised beds and cover the seed lightly with soil or rice hull
- Water the seedbed till saturation after sowing
- Then water the bed periodically as seedlings emerge and grow
- Regulate the water supply, if necessary, to control the rate of seedling growth
- Apply pesticides to control pests, if needed
- Seedlings are ready from 25-30 DAS

Dapog (Mat) Nursery

Dapog (mat) Nursery

- Select a level area near the household and/or a water source
- Mark out 1 m wide and 10 to 20 m long plots
- Spread a plastic sheet or banana leaves on the marked area
- Form the boundary with bamboo splits or banana sheath
- Spread the pre-germinated seeds at the rate of 1 kg per 1.5 m^2 area
- 40-50 kg seed sown in 60-75 m^2 area is enough to plant one ha of the main field
- Sprinkle water immediately after sowing and then as and when needed
- Protect the mat nursery from heavy rains for the first 5 DAS
- Seedlings will be ready for sowing in 8 to 15 DAS
- Roll out the seedling mats and transport them to the main field

Seedling Broadcasting (SB)

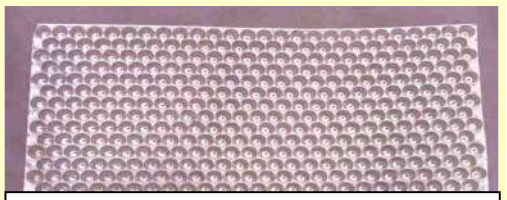


Fig. A Plastic Bubble Tray

- 12-15 days old seedlings with root balls
- Seedlings raised on plastic trays
- Size: 59 cm x 34 cm with 434 embedded holes
- 750 trays ha^{-1}
- Seed bed area: 250 m^2 to plant one ha
- Nursery in uplands, lowlands or near the house
- In lowlands, 75 cm wide and 9-12 cm high seed beds are used

Seedlings with root balls

Skill Set (Agron) 4: Mechanical weed control

Mechanical or physical methods of weed control are being employed ever since man began to grow crops. The mechanical methods include tillage, hoeing, hand weeding, digging, sickling, mowing, burning, flooding, mulching etc. Out of these, some of the important methods are described below:

Mechanical tillage

1. Tillage

Tillage removes weeds from the soil resulting in the air death. It may weaken plants through injury of root and stem pruning, reducing their competitiveness or regenerative capacity.

Tillage also buries weeds. Tillage operation includes ploughing, discing, harrowing and leveling which is used to promote the germination of weeds through soil turnover and exposure of seeds to sunlight, which can be destroyed effectively later. In case of perennials, both top and underground growth is injured and destroyed by tillage.

2. Hoeing

Hoe has been the most appropriate and widely used weeding tool for centuries. It is, however, still a very useful implement to obtain results effectively and cheaply. It supplements the cultivator in row crops. Hoeing is particularly more effective on annuals and biennials as weed growth can be completely destroyed. In the case of perennials, it destroyed the top growth with little effect on underground plant parts resulting in re-growth.

Hand hoeing

3. Hand weeding

It is done by physical removal or pulling out of weeds by hand or removal by implements, for example, *khurpi*. It is probably the oldest method of controlling weeds and it is still a practical and efficient method of eliminating weeds in cropped and non-cropped lands. It is very effective against annuals and biennials, and controls only upper portions of perennials.

Hand weeding

4. Digging

Digging is very useful in the case of perennial weeds to remove the underground propagating parts of weeds from the deeper layer of the soil.

5. Sickling and mowing

Sickling is also done by hand with the help of sickle to remove the top growth of weeds to prevent seed production and to starve the underground parts. It is popular in sloppy areas where only the tall weed growth is sickled leaving the root system to hold the soil in place to prevent soil erosion. Mowing is a machine-operated practice mostly done on roadsides and in lawns.

6. Burning

Burning or fire is often an economical and practical means of controlling weeds. It is used to (a) dispose of vegetation, (b) destroy dry tops of weeds that have matured (c) kill green weed growth in situations where cultivations and other common methods

are impracticable**.**

7. Flooding

Flooding is successful against weed species sensitive to longer periods of submergence in water. Flooding kills plants by reducing oxygen availability for plant growth. The success of flooding depends upon the complete submergence of weeds for longer periods.

Skill Set (Agron) 5: Herbicide application in agricultural crops

Chemicals that are used to control weeds or the growth of undesirable grass or plants are called herbicides. Modern weed killers are put in two categories: selective (affecting specific plant species) and nonselective (affecting plants generally). These, in turn, are classified as foliage-applied and soil herbicides.

METHODS OF APPLICATION

1. Soil application of herbicides:

(i) Surface application: Soil active herbicides are applied uniformly on the surface of the soil either by spraying or by broadcasting. The applied herbicides are either left undisturbed or incorporated into the soil. Incorporation is done to prevent the volatilization and photo-decomposition of the herbicides.

(ii) Subsurface application: It is the application of herbicides in a concentrated band, about 7-10 cm below the soil surface for controlling perennial weeds. For this method, a special type of nozzle is introduced below the soil under the cover of a sweep hood.

(iii) Band application: Application to a restricted band along the crop rows leaving an untreated band in the inter-rows. Later inter-rows are cultivated to remove the weeds.

(iv) Fumigation: The application of volatile chemicals into confined spaces or into the soil to produce gas that will destroy weed seeds is called fumigation. Herbicides used for fumigation are called as fumigants. These are good for killing perennial weeds and as well for eliminating weed seeds.

(v) Herbigation: It is the application of herbicides with irrigation water both by surface and sprinkler systems.

2. Foliar application

(i) Blanket spray: It is the uniform application of herbicides over the entire leaf area. Only highly selective herbicides are applied by this method.

(ii) Directed spray: It is the application of herbicides on weeds in between rows of crops by directing the spray only on weeds avoiding the crop. This could be possible by use of protective shield or hood.

(iii) Protected spray: It is a method of applying non-selective herbicides on weeds by covering the crops which are wide spaced with polyethylene covers etc. This is expensive and laborious. However, farmers are using this technique for spraying glyphosate to control weeds in jasmine, cassava, banana.

(iv) Spot treatment: It is usually done on small areas having serious weed infestation to kill it and to prevent its spread. Rope wick applicator and herbicide glove are useful here.

Before herbicide application

After herbicide application

Skill Set (Agron) 6: Field demonstration on soil and moisture conservation measures

Soil and water are essential for all terrestrial life, providing the basic resources needed for food, feed, fuel, and fibre. Soil supports plant growth and development; but is a non-renewable resource vulnerable to rapid degradation through various forms of erosion. Hence, the conservation of soil and water is very much need of the hour.

Types of soil and moisture conservation measures

1.	Agronomic/ Agroforestry/ Biological measures	:	Contour farming, Ridge and furrow, Cover crops, Intercropping, Mulching, Agroforestry measures
2.	Mechanical/ Engineering measures	:	Bunding, Contour trenching, Bench terracing

1. Types of Agronomic/ Agroforestry/ Biological measures

i. Contour farming:

Contour farming

- Follow all the agricultural operations viz. ploughing, sowing, inter-culture, etc., along the contour line.
- The ridges and furrows formed across the slope will act as a continual series of small barriers to the flowing water which reduces the velocity of runoff and thus reduces soil erosion and nutrient loss.

ii. Ridge and furrow system:

Ridge and furrow system

- Grow rainy season crops like maize, millets, cotton, etc. on ridges and *rabi* season crops like vegetables in furrows.
- This reduces the soil crusting and ensures good crop stand over sowing on flat beds.
- Inter-row rainwater can be drain out properly during the monsoon period and collected in farm ponds, for life-saving irrigations and profile recharging for the establishment of *rabi* crops.

iii. Cover crops:

Cover crops

- Grow close-growing crops having high canopy density for protection of soil against erosion.
- Follow higher seed rate for cover cropping (e.g. dhaincha @ 45-50 kg/ha; sunnhemp/cowpea/black gram/ green gram @ 30-35 kg/ha)

- Legume crops have better biomass to protect soil than cereal crops and interception of raindrops which helps in reducing the exposure of soil surface to erosion.

iv. Intercropping:

Intercropping of maize and soybean

- Grow erosion-permitting crops like maize, sorghum, etc with erosion-resisting crops like soybean, cowpea, black gram, green gram, etc. simultaneously in the same field with definite or alternate row pattern.
- For example, one row of soybean/cowpea/black gram/ green gram, etc. can be sown in inter-row space between two rows of maize.
- Both crops should have different rooting patterns, nutrient demand, and maturity periods.
- Intercropping provides better coverage on the soil surface, reduces the direct impact of raindrops, and protects soil from erosion.

v. Mulching:

- Mulching covers the soil surface to protect the soil from being eroded away, reduce evaporation, increase infiltration, regulate soil temperature, improve soil structure, and thereby conserve soil moisture. It prevents the formation of hard crust after each rain.

Straw mulching

- For organic mulching, apply organic materials like straw, leaves, etc. on the soil surface.
- Cover the space between rows thoroughly, but not right up to the plant stems, which can encourage fungal diseases to take hold.
- A good rule of thumb is to leave one to three inches of space around plant stems to provide good air circulation and avoid rots.
- Add more straw, if needed, during the growing season
- For inorganic mulching, use inorganic materials like plastic sheet, stone/gravels, etc.

Plastic mulching

Stone and gravel mulching

- For plastic mulching, puncture the plastic sheet at the required distances as per the crop spacing.
- Lay the punctured plastic sheet on the well-prepared bed and fix all the sides with soil.
- Sow the seeds directly or transplant seedlings in the holes.
- Very thin film (15-20 microns thick) is used for short-duration crops like vegetables.

vi. Agroforestry measures:

- In Agroforestry, trees or shrubs are cultivated with agricultural crops and livestock production simultaneously on the same piece of land.

- The leaf litter addition acts as a protective layer against soil erosion improves soil health and moisture retention capacity of the soil and increases crop productivity.
- In fruit orchards, field crops like cowpea, green gram, etc. can be grown along with fruit trees.


Agroforestry

2. Mechanical/ Engineering measures

Mechanical measures, or engineering structures, are designed to modify land steep slopes (more than 2%), safely convey runoff water to waterways, reduce sedimentation and runoff velocity, and improve water quality. These measures can be used alone or in combination with biological measures to enhance the performance and sustainability of erosion control efforts.

Types of Mechanical/ Engineering measures

i. Bunding:

- Bunds are made to drain out of excess runoff water safely.
- This is applicable in areas having land slope up to 10% and receiving rainfall of >750 mm with the soils having infiltration rate < 8 mm/hr.

Bunding

ii. Contour trenching:

- Trenches are constructed at the contour line to reduce the runoff velocity for soil moisture conservation in the areas having <30% slope.
- Bunds are formed on the downstream side of trenches for the conservation of rainwater.


Contour trenching

iii. Bench terracing:

- Terraces are earthen embankments built across the dominant slope partitioning the field in uniform and parallel segments.
- Generally, these structures are combined with channels to convey runoff into the main outlet at reduced velocities.
- It reduces the degree and length of slope and thus reduces runoff velocity, and soil erosion and improves water infiltration.
- It is recommended for lands having a slope of up to 33% but can be adapted for lands having up to 50–60% slope, based on the socio-economic conditions of a particular region.
- Where plenty of good-quality stones are available, stone bench terracing is recommended. Sometimes, semi-circular type terraces are built at the downstream side of the plants, known as half-moon terraces.

Bench terracing

Skill Set (Agron) 7: Identification of weeds in crops

Weeds pose serious threats to both agriculture and the environment. Of the 826 weed species reported in the country, 80 are considered very serious and 198 as serious. Weeds account for up to 37 percent of total agricultural pest losses. Unlike other pests, weeds are ubiquitous and affect nearly all crops. On average, weeds reduce crop yields by 31.5 percent, with losses of 22.7 percent in the winter season and 36.5 percent in the summer and kharif seasons. Weed composition and competition are dynamic, influenced by soil, climate, cropping patterns, and management practices. Consequently, weed management strategies must be tailored to each agroecological condition.

Characteristics of weed plants:

1) The weed seeds germinate early and the seedlings grow faster as compared to the main crop since they can absorb more nutrients, water, and sunlight as compared to the main crop.
2) They flower earlier, run to seed in profusion, and mature ahead of the crop when there are stress conditions. Such weed plants are called ephemeral weeds (Example: *Phyllanthus nauri*)
3) They are un-useful, unwanted, and undesirable however some weed plants have medicinal value as well as used as vegetables. Such plants are called beneficial weeds. (Example: Amaranthus, Chenopodium)
4) They are harmful to crops, cattle and human beings through their trichome and pollen grains (Example: Parthenium / Congress grass)
5) They can survive even under adverse conditions and they have more seed viable period. Examples seeds of parthenium, amaranthus, sedge grass, Bermuda grass, etc.

6) They are prolific and have a very high reproductive capacity as well and their underground propagules are difficult to control (Example. Sedge grass)
7) The viability of seeds remains intact, even if they are buried deep in the soil.
8) The seeds may have special structures like wings, spines, hooks, sticky hairs etc. on account of which they can be easily disseminated over long distance (Example. Milk weed, Congo grass)
9) Weed plants belonging to the Graminaceae / Poaceae family belong to C_4 plant which can absorb more nutrient, soil moisture and sunlight resulting suppressed the plant growth.

List of major weeds commonly found in Agronomic Crops

Sl. No.	Name of weed	Description	Affected Crops	Photograph
Grassy Weeds				
1	*Phalaris minor* (Little seed canary grass)	An annual grassy weed with slender leaves and dense spike-like inflorescences	Wheat, barley, oats	
2	*Echinochloa crusgalli* (Barnyard grass)	An annual grassy weed with broad leaves and branched, spreading seed heads	Rice, maize, sugarcane	
3	*Eleusine indica* (Indian goosegrass)	A tufted annual grassy weed with flattened stems and finger-like seed heads	Maize, millet, sorghum	
4	*Cynodon dactylon* (Bermuda grass)	A perennial grassy weed with deep roots and fine, flat leaves.	Maize, sugarcane, cotton	
5	*Paspalum distichum* (Knotgrass)	A perennial grassy weed with creeping stems and paired spikelets	Rice, sugarcane, sorghum	
Broadleaf Weeds				
1	*Parthenium hysterophorus* (Congress grass)	An annual broadleaf weed with finely lobed leaves and small white flowers.	Cereals, pulses, oilseeds	

2	*Amaranthus* spp. (Pigweed)	Broadleaf weeds with thick, erect stems and alternate leaves, producing dense clusters of small flowers.	Maize, soybean, cotton	
3	*Chenopodium album* (Lamb's quarters)	An annual broadleaf weed with triangular leaves and dense clusters of greenish flowers	Wheat, barley, maize	
4	*Convolvulus arvensis* (Field bindweed)	A perennial broadleaf weed with climbing or creeping stems and white or pink funnel-shaped flowers	Wheat, maize, sugarcane	
5	*Lantana camara* (Lantana)	A perennial shrub with square stems, aromatic leaves, and clusters of small, brightly colored flowers	Coffee, tea, cotton	
Sedges				
1	*Cyperus rotundus* (Purple nutsedge)	A perennial sedge with dark green, shiny leaves and purple-brown seed heads.	Rice, maize, cotton	
2	*Cyperus esculentus* (Yellow nutsedge)	A perennial sedge with bright green leaves and yellowish-brown seed heads.	Rice, maize, soybean	
Notable Weeds				
1	*Argemone mexicana* (Mexican poppy)	An annual broadleaf weed with spiny leaves and bright yellow flowers	Wheat, barley, maize	

2	*Commelina benghalensis* (Benghal dayflower)	A prostrate or ascending perennial with succulent stems, oval leaves, and blue flowers.	Sugarcane, maize, cotton	
3	*Xanthium strumarium* (Common cocklebur)	An annual broadleaf weed with rough stems, large leaves, and spiny burs.	Soybean, maize, cotton	
4	*Dactyloctenium aegyptium* (Crowfoot grass)	An annual grassy weed with creeping stems and distinctive seed heads.	Rice, wheat, maize	
5	*Imperata cylindrica* (Cogongrass)	A perennial grassy weed with sharp, erect leaves and fluffy white seed heads	Sugarcane, maize, rice	

Skill Set (Agron) 8: Threshing of paddy

Rice threshing is the process of separating the grain from the straw. It can be either done by hand, by using a treadle thresher or threshing machine.

A. Manual threshing: The common method for manual threshing is

hand beating against an object, treading, or holding the crop against a rotating drum with spikes or rasp bars. For hand-threshed crops, partial drying in the field for a couple of days may be necessary to lower the moisture content and make threshing easier. The highest milling yield will be attained for hand-threshed, sun-dried rice at a grain moisture content between 18–20%.

Pedal thresher**:** The pedal or treadle thresher consists of a threshing drum, base, transmission unit, and a foot crank. When pedalled, the threshing drum rotates and rice can be threshed when panicles are applied against the threshing drum. Because small straws, chaff, and foreign matter drop along with the threshed grain, whole grains must be separated using a flail, sieve or by winnowing.

Trampling

This involves the use of bare feet or animals to thresh the crop. The crop is spread over a mat or canvass and workers trample with their own feet or use their animals. Animal treading or trampling is normally carried out at a

designated location near the field or in the village. In some regions, animals have been replaced by tractors. After animal treading, the straw is separated from the grains and cleaning of the grain is done by winnowing, with or without the aid of an electric fan. Losses are high from broken and damaged grains.

Threshing rack

The crop is held by the sheaves and beats it against a slatted bamboo, wooden platform, or any other hard object such as a steel oil drum. This is very labor intensive.

B. Machine threshing: The use of small stationary machine threshers commonly replaces manual threshing given the high labor requirements of manual threshing. Stationary threshing is generally done in the field, or near the field. Many stationary threshers for paddy have peg-toothed threshing drums, however, threshers fitted with wire-loop or rasp bars are used as well. Most threshers are of the feed-in type (e.g. entire crop is fed through the thresher) which ensures high throughput. The grain should be harvested at optimum maturity to maximize yield and minimize losses. Ideally, machine threshing should begin immediately after cutting and often these crops can be threshed in the field. Always make sure that the threshing drum speed and the cleaner settings are done properly according to the crop conditions. Wrongly adjusted threshers create higher threshing loss and grain damage.

Hold-on threshers (only panicle is fed into the machine) generally have a lower capacity than feed-in threshers and are primarily used in areas where rice straw is bundled and stored for later use.

Large stationary threshers are fitted with additional cleaning devices such as an oscillating screen, centrifugal blower, and windboard, and threshed grain can be handled without further cleaning. One such type is the feed-in type axial-flow thresher. In this type, the harvested crop is loaded onto the tray and fed into the opening between the cylinder and the concave at one end of the machine. The pegs on the threshing cylinder hit the material separating the grain from the straw, and at the same time accelerating them around the cylinder.

The majority of the grain is threshed during initial impact but further threshing is performed as the material moves axially until the straw is discharged at the opposite end. Threshed grain, including impurities such as leaves and short pieces of straw, pass through the openings in the concave and fall on the oscillating screen where large impurities are separated.

Skill Set (Agron) 9: Winnowing of paddy

Winnowing: Wind winnowing is an agricultural method for separating grain from chaff. It is also used to remove weevils or other pests from stored grain. In its simplest form it involves throwing the mixture into the air so that the wind blows away the lighter chaff, while the heavier grains fall back down for recovery. Techniques included using a winnowing fan (a shaped basket shaken to raise the chaff) or using a tool (a winnowing fork or shovel) on a pile of harvested grain. Winnowing can be done either manually or by machines.

A. Manual or hand winnowing: The traditional way of winnowing is making the dried grains fall from a height using shovels and a sieve. The quality grains which are heavy fall vertically while the weightless chaff and straw get blown away by the wind. Thus, this method is effective only when there is a wind.

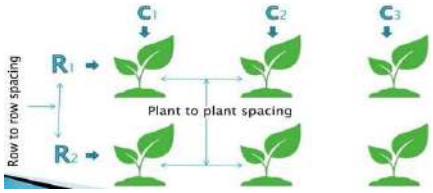
B. Machine winnowing: This machine winnows the paddy already threshed by a paddy thresher or other means. It has a feeding hopper at the top to receive the threshed paddy with other impurities. It discharges the threshed paddy over a scalper and removes bigger size impurities. A blower provided at bottom sends a stream of air against the grain falling through the scalper, which separates the straw, chaff and other impurities. The dust, chaff and straw are collected separately and cleaned paddy is taken out through another outlet near the bottom of the unit.

Skill Set (Agron) 10: Skillset on Crop Geometry

To impart the knowledge of different arrangement of plants in different rows and columns.

Introduction

The arrangement of the plants in different rows and columns in an area to efficiently utilize the natural resources is called crop geometry. It is otherwise an area occupied by a



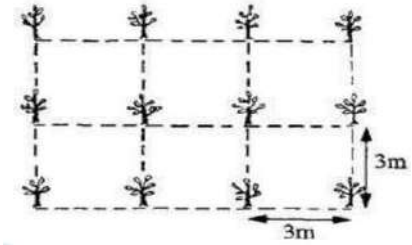
single plant. This is very essential to utilize the resources like light, water, nutrient and space. Different geometries are available for crop production.

Different types of crop geometries

1) Random plant geometry

Literally means scattering the seeds. Obtained due to broadcasting method of sowing. Broadcasting is mostly followed for small sized to medium sized crops. Results in random geometry, no equal space is maintained, resources are either under exploited or over exploited.

2) Square method or square geometry



The plants are sown at equal distances on either side. Mostly perennial crops, tree crops follow square method of cultivation.

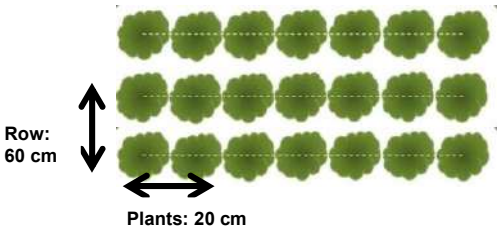
Advantages

i) Light is uniformly available,

ii) Movement of wind is not blocked and

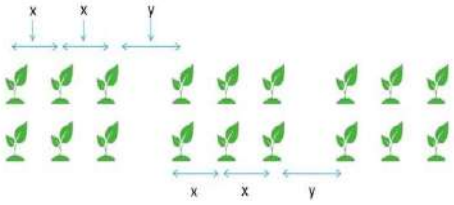
iii) Mechanization can be possible.

3) Rectangular method of sowing

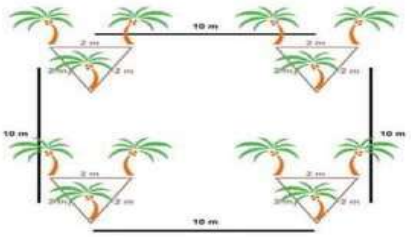


There are rows and columns, the row spacing are wider than the spacing between plants. The different types exist in rectangular method

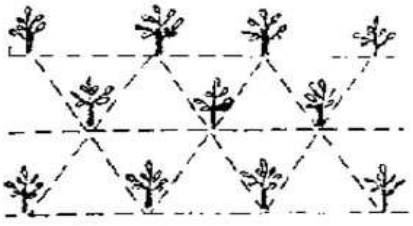
4) Paired row arrangement – May involve square or rectangular sowing. Space available between set of row can beused to plant inter—crop



5) Triangular method of planting - It is recommended for wide spaced crops like coconut, mango, etc. The number of plants per unit area is more in this system.



6) Diamond pattern- A diamond picture is formed by joining all plants so named “diamond”. It is modified form



of square pattern of crop geometry which can have an additional plant in between.

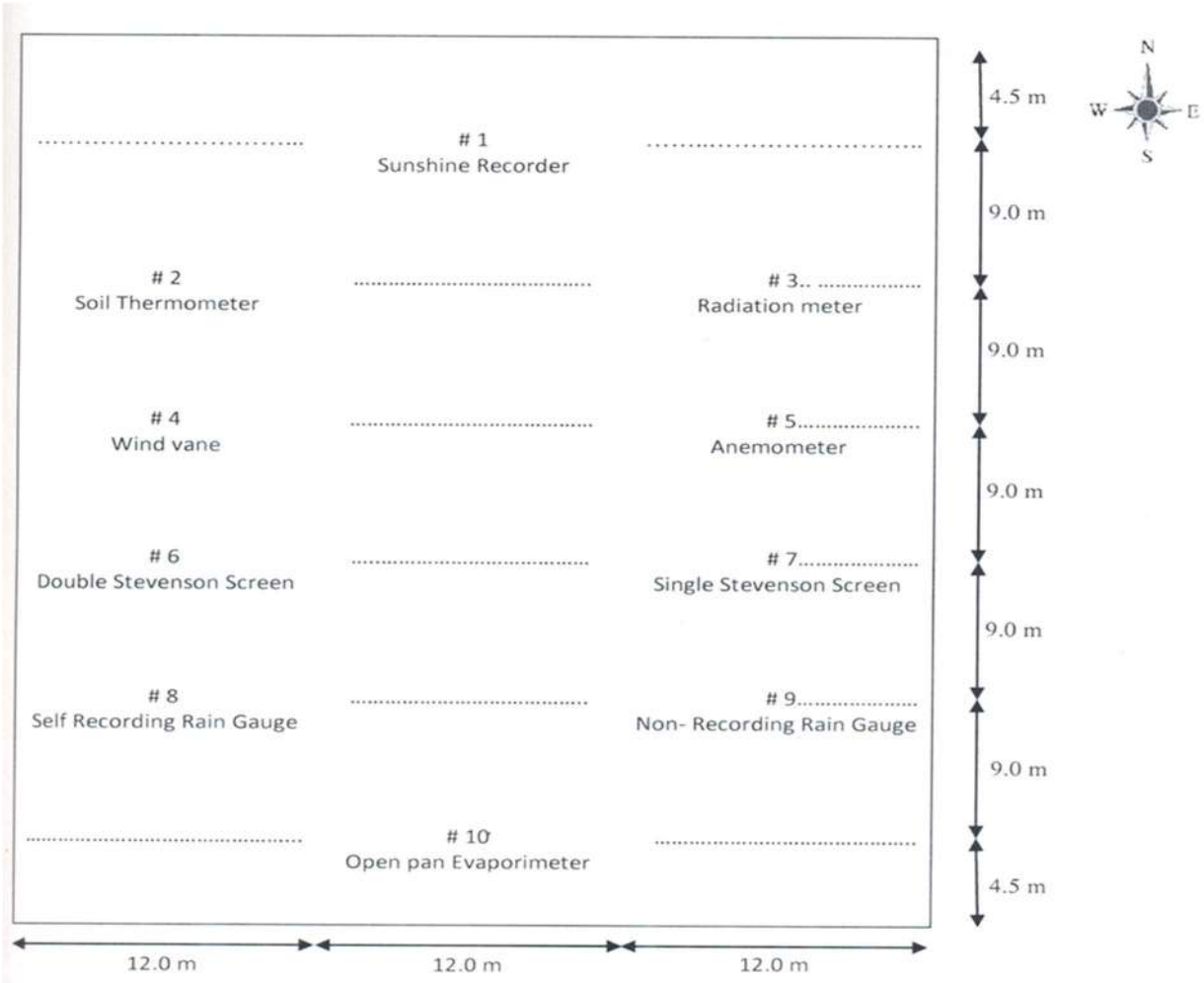
Skill Set (Agron) 11: Demonstratation of instruments in the Agrometeorology observatory

Objective:

a) To study about meteorological observatories
b) To know that quality and quantity of any crop production mainly depend on weather.

The surface observatories are letter coded into six classes.

a) Class A: Observatories: These are provided with eye reading instruments and self-recording instruments. The observations are recorded every after hour round the clock.
b) Class B: Observatories: Most of these are furnished with eye-reading instruments and self-recording instruments. Regular observations are made at least twice a day.
c) Class C: Observatories: These have the same instruments or equipment that of described in Class B Observatories but observations are recorded only once a day.
d) Class D, Class E and Class F Observatories: These have a smaller number of instruments or equipment's or are non- instrumental



LAY OUT OF AGROMETEOROLOGY OBSERVATORY

Raingauge

Sunshine Recorder

Open Pan evoporemeter

Guidelines to Observer:

a) Sufficient water should be available in the container below the wet bulb thermometer, if it is not sufficient then pour distilled water in the bottle and take the reading after 10 minutes.
b) Periodically change the muslin cloth crochet thread.
c) Water in the OPE (Open Pan Evaporimeter) tank should be changed after every 15 days.
d) Oiling and cleaning of the wind instruments should be done every month.
e) Maximum temperature to be recorded at hr I (0700 LMT) and minimum temperature to be recorded at hr II (1400 LMT) set maximum temperature at hr I (0700 LMT) and minimum temperature of hr II of previous day.
f) Maximum temperature is generally more or equal to dry bulb temperature of hr II of previous day. Minimum temperature is generally less or equal to dry bulb temperature of hr I of same day. Check these, while recording observations. If there is any break in column remove it.
g) Soil temperatures of 5 cm depth are generally more than the corresponding reading of dry bulb temperatures. Generally, soil temperature of hr I increases with depth.
h) Humidity and Dew point temperatures can be calculated with the help of a Hygrometric table of the station height.
i) Sunshine data should be entered in CWS - I form at column 24 of the previous day i.e. the sunshine data of the card removed on 5th morning should be entered in CWS - I form against 5th in three digits viz. 000, 04.5, 10.0 etc.
j) Rainfall past 24 hrs should be addition of yesterday's evening (1400 LMT) ram and today's (0830 1ST) morning rain. Rainfall should be copied in four digits in column 25 e.g., 0000, 001.2, etc.
k) Mean velocity in kmph for past 24 hrs up to one decimal point.
l) Direction recorded should be recorded in points of compass e.g., N = 36, NE = 05 etc.

Site selection criteria for agro-meteorological observatory:

a) The site should be well exposed, bare levelled plot having the length of South direction and the width of 36 m in East-west direction
b) It should represent the natural soil topography and under no circumstances concrete, asphalt or crushed rock layers.
c) Wherever the local climate and soil do not permit a grass cover, the ground should have natural cover.
d) It should be located more or less at the centre of the research farm
e) The site should be well away form the buildings, structures, high hills, water tanks, etc.
f) Under unavoidable circumstances, site may select in such way that the distance should be more than 10 times of the instrument's height.
g) During monsoon or rainy season, the site should be free from water submergence.

h) Entry of the animals should be protected by using barbed wire fencing in order to avoid disturbance of the observatories.

Skill Set (Agron) 12: Techniques for soil moisture conservation

Objectives:

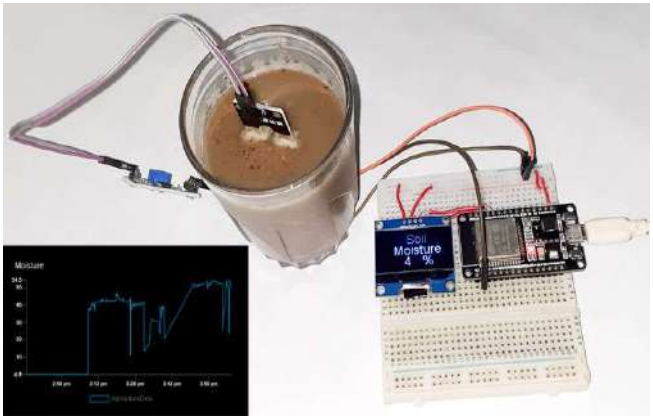
a) To measure important parameters of soil like soil moisture, soil temperature, soil pH, soil conductivity and soil nutrients (NPK)

Activities:

a) Study the soil types found in dryland and rainfed agriculture
b) Study the soil characteristics
c) Analyze the soil for physical properties
d) Field demonstrations of agronomic and mechanical measures for soil moisture conservation
e) Demonstration on water harvesting techniques

Use of IOT-based monitoring and record of soil moisture practices

a) Internet of Things (IoT)-based soil moisture monitor that observes soil moisture level using Arduino Uno microcontroller and a Wireless Fidelity (Wi-Fi) module to send data from the board to the user's cell phone or Personal Digital Assistant (PDA).



b) The soil moisture monitor works by observing the water level of the soil and alerts the farmer when the predefined threshold rate of the moisture sensor goes above or beneath, thus indicating over-watering and groundwatering.
c) The design and development of an IoT device with integrated machine learning capabilities for continuously monitoring soil moisture, humidity, temperature, and NPK levels using three different sensors.
d) This device provides real-time data, enabling precise and timely agricultural decision-making.

Hardware requirements:

a) Moisture Sensor
   - Soil moisture sensor measures the volumetric water content in the soil.
   - This sensor is made up of two probes which is used to ration the volumetric content of water.
   - These probes are dipped into the soil which permits current to pass through the soil to get the resistance value used to obtain moisture value.
   - If the water level is high, the soil conducts electricity more, which means that the resistance of the soil will be low,

therefore, the moisture content is high.

b) EC sensor

- The soil EC sensor is a high functional and digital display soil meter, it can quickly test conductivity of different kinds of soil.
- The soil EC meter is precision, quick, stable, wide range, display clear, portable and easy to test.

c) pH Sensor

- Soil pH sensors are commonly used agricultural smart devices used to monitor soil pH values.
- By accurately obtaining soil pH information, which is a crucial factor for plant growth and development, farmers can take timely measures to adjust soil acidity or alkalinity, thereby improving crop growth and yield.
- This article will introduce the definition of soil pH sensors, their working principles, and their applications in various fields.

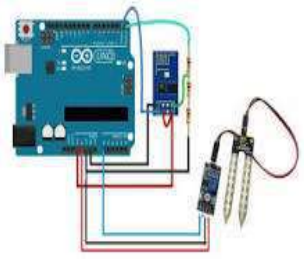
d) Arduino Uno

- Arduino Uno is an ATmega328P microcontroller board with 14 digital input or output pins (6 can be used, for example, as outputs for Pulse Width Modulation), 6 analog inputs, 16MHz quartz crystal, USB connection, a power jack, ICSP header and a reset button.
- The Arduino Uno board is the main functioning system in this monitor as it reads and deduces the data from the soil sensor outputs. Arduino Uno can be powered through the USB connection or from the use of an external power supply

e) DS18B20 Sensor

- It is a reliable and accurate sensor that is widely used in a variety of applications.
- The DS18B20 Waterproof Temperature Sensor Kit is widely used in many fields, such as soil temperature measurement, hot tank temperature control etc.
- It supports multipoint measurement.

f) Wi-fi module



- ESP8266 is a Wi-Fi module which is often used for IoT applications and function as a microcontroller to link directly to Wi-Fi and create a TCP/IP connection.
- It has an on-board processing and storage unit which permits integration with other sensors and application devices through its general purpose input/output (GPIOs) with negligible loading during runtime.

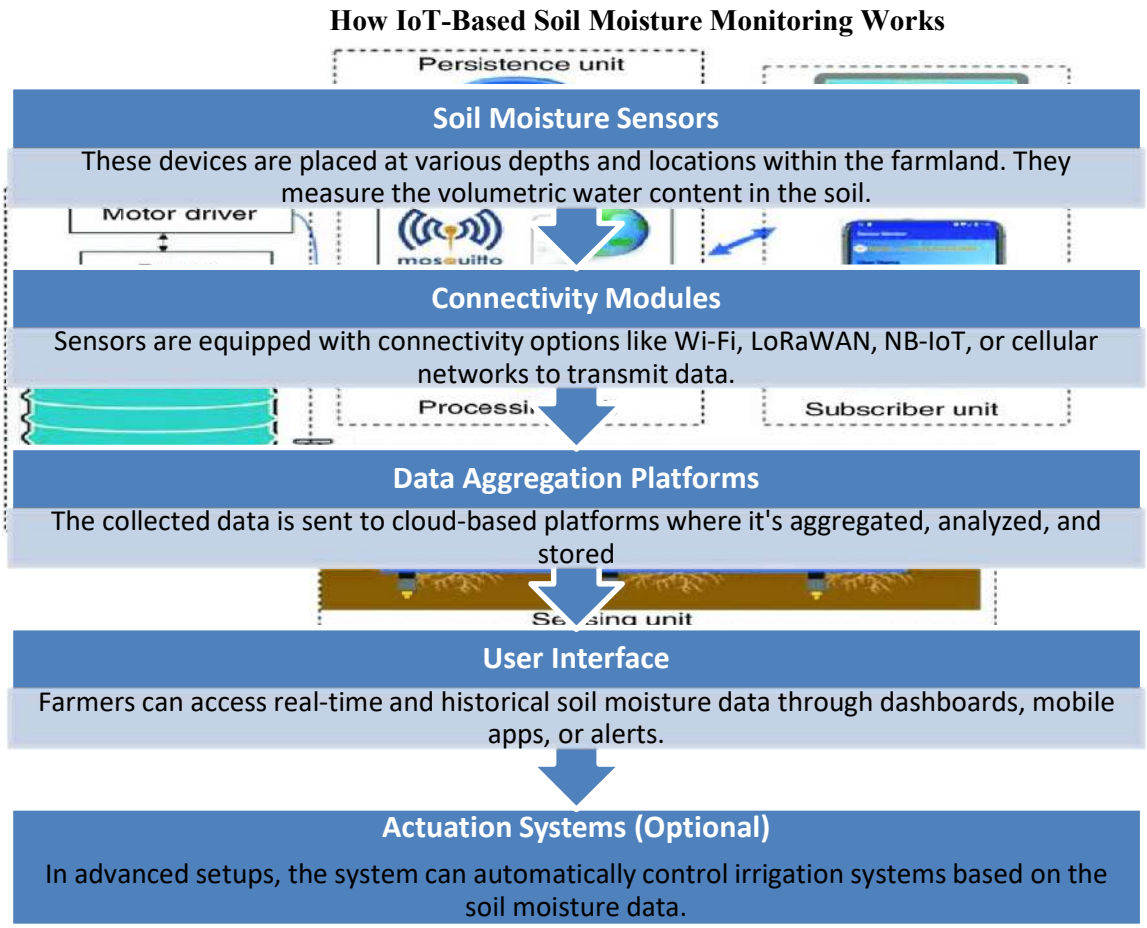


Figure 1. A model of smart IoT based irrigation system (Khriji et al., 2021)

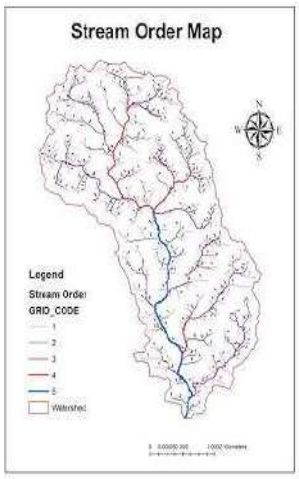
Skill Set (Agron) 13: To delineate the watershed and its management

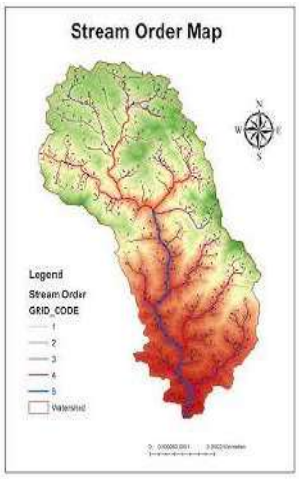
Objectives:

a) To understand the concept and methodology for watershed delineation
b) To delineate the sub-watershed within a watershed by using topographic sheets and modern techniques like Remote Sensing, GIS, GPS, Etc.

Activities:

a) Determine the watershed using maps indicating the river border and boundary:
b) Prepare a map indicating contour lines:
c) Map pointing out contour lines towards higher:
d) Identify break points:
e) Prepare a map of Imaginary boundary of watershed
f) Identify the sub water shed and prepare a final watershed image





Requirements:

- SOI Topo-graphic sheet of study area
- GPS Receiver Set/ Grid Elevations collected through GPS survey
- Remote sending satellite image and
- Computer system with GIS software

Following steps are used for watershed delineation:

a) In a topo sheet, location is mark for the water body or tributary joining the main stream
b) The contour lines on the topo sheet for the area will be studied i.e. lines connecting points of equal elevation above mean sea level or GTS Benchmark.
c) The contours that point downstream indicates ridges, contour that point upstream indicate valley, contour spaced far apart indicate the landscape which is more or less flat and the contour lines spaced very close together indicate sudden changes in elevation i.e. the area with steep slopes.
d) Touch the drainage line or waterway from its catchment source to its outlet including the tributaries.
e) A valley line or drainage line is represented by a series of contour lines "Pointing" towards the highest elevation. It determined the direction of drainage in the area by drawing arrows perpendicular to a series of contour lines that decrease in elevation.
f) Higher area or ridge line represent by a series of contour lines "pointing" towards the lowest elevation.
g) Identify and mark the divide points/highest elevations where part of the runoff would drain towards one body of water and the rest to another body of water.
h) Connect the divide points to form the line of highest elevations in the area which is called as watershed boundary
i) Here, the process of watershed delineation through topo sheet is complete
j) For accurate technology and learning point of view, we can used GPS, Remote Sensing and GIS to delineate the sub-watersheds.
k) Extract and digitize the base map of the area into the GIS vector layers.
l) Overlay the Remote Sensing Image over the area to detect the changes in the topography of the area and lastly update the information.
m) Put the GPS collected Grid elevations over the base map to generate the contour map of desired contour interval.
n) Create DEM (Digital Elevation Model) for the area to have the view of topography of the area which will present the delineated watersheds/sub-watersheds of the area. The process is same as GIS but it will be automated.
o) Now, this delineated watershed or sub-watershed map can be taken to the field for verification.

Different measurements like total number and length of channels watershed boundary, etc. and convert to the actual length as per the map scale.

Skill Set (Agron) 15: Certification of organic farming

How to identify suitable farmer and suitable certifying body?

Large scale farmers or small size landholder grower's groups (minimum of 25 and maximum of 500 farmers having land in the same geographical area) can apply for organic certification of their produce. The product produce from that farm is certified as organic.

Certification process:

The certification is issued by testing centres accredited by the Agricultural and Processed Food Products Export Development Authority (APEDA) under the National Program for Organic Production (NPOP) of the Government of India.

1. Receipt of application form**:** Farmers need to apply for the certification board. A written annual production plan must be submitted, detailing everything from seed to sale (seed sources, field and crop locations, fertilization and pest control activities, harvest methods, storage locations, etc.)
2. Scrutiny and registration of application**:** The application received along with the other farm or field details are verified by the inspector. This application is forwarded for the registration if all the requirements are fulfilled. For the registration the farmer must pay a prescribed amount. Once the farm is registered it must be strictly maintained under the organic conditions only.
3. Inspection and evaluation of the farms and documents: Annual on-farm inspections are required, with a physical tour, examination of records, and an oral interview is done. The farmer must be available for inspection at any time. In addition, short-notice or surprise inspections can be done by the certification officer.
4. Sampling of soil, water and plant products if necessary: Analysis of plant and soil sample will be done and if the results indicate the presence of any chemicals or toxic substance then their certificate will be taken back.
5. Issue of certificate to eligible organic farms: If the grower has maintained his farm purely under organic conditions, then a certificate will be given to him assuring others that he is an organic grower. The certificate is online generated, and it takes around six months from the date of application.

Labeling and Marketing

1. 100 Percent Organic

- Product that contains 100 percent organic ingredients (excluding salt and water, which are considered natural)
- Most raw, unprocessed or minimally processed farm crops can be labeled "100 percent organic"

2. Organic

- Any product that contains a minimum of 95 percent organic ingredients (excluding salt and water)
- Up to 5 percent of ingredients may be nonorganic agricultural products and/or nonagricultural

Marketing

Marketing organic produce requires a sound knowledge of your product, the market and your target audience

There are three essential rules for marketing organic products:

- know your product's performance and nature
- know the regulatory requirements
- know your customers.

Skill set (Agron) 16: Technique of using GIS Technology

Objectives:

To manage, analyze and visualize spatial and geographic data related to agricultural activities in order to enhance farming practices, improve efficiency, and increase productivity.

Procedure:

GIS can be used in agriculture in the following ways:

Precision Farming*:* GIS helps in precision farming by providing detailed maps and data analysis for managing crops at a very granular level. This includes analyzing soil types, moisture levels, and nutrient availability to optimize the application of water, fertilizers, and pesticides.

Crop Monitoring and Management*:* GIS can track crop health, growth patterns, and yields over time. Satellite imagery and aerial surveys can be integrated into GIS to monitor crop conditions and detect issues like diseases or pests early.

Soil Analysis**:** GIS allows for detailed mapping of soil properties, including pH levels, texture, and organic matter content. This information helps farmers make informed decisions about soil management and crop selection.

Water Management*:* GIS is used to manage irrigation systems more effectively by analyzing water usage patterns, identifying potential sources of water, and planning irrigation schedules. It can also help in managing water resources and preventing issues like runoff and erosion.

Farm Planning and Management: GIS can assist in the design and management of farm layouts, including the placement of crops, fields, and infrastructure. It helps in optimizing land use and improving farm operations.

Yield Prediction and Analysis**:** By analyzing historical yield data and current environmental conditions, GIS can help predict future crop yields. This aids in planning and decision-making for both farmers and agricultural businesses.

Environmental Impact Assessment**:** GIS helps in assessing the environmental impact of farming practices. It can be used to analyze factors such as habitat disruption, soil erosion, and water contamination, helping to develop more sustainable agricultural practices.

Market Analysis and Logistics**:** GIS can support the analysis of market trends and optimize supply chain logistics by mapping transportation routes, market locations, and distribution networks.

Implementing GIS in agriculture involves a series of structured steps to ensure the effective utilization of spatial data and technology. Here's a general outline of the steps involved:

1. Define Objectives and Needs

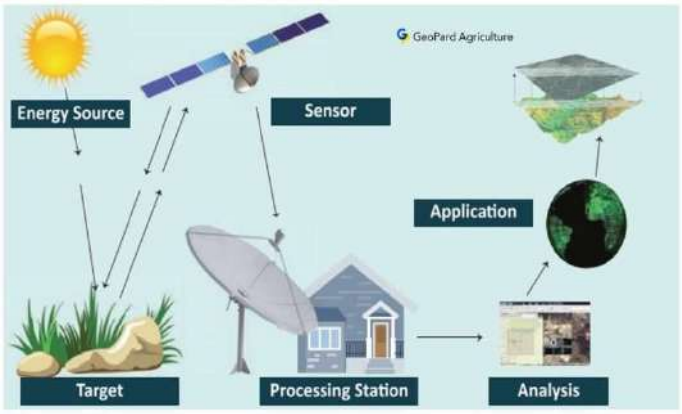
Identify Goals: Determine what specific agricultural problems or objectives need to be addressed using GIS (e.g., improving yield, managing irrigation, optimizing fertilizer use).

Scope and Requirements: Define the scope of the GIS project and gather requirements based on the needs of the farm or agricultural business.

2. Data Collection and Acquisition

Gather Spatial Data: Collect spatial data relevant to the agricultural objectives, such as soil properties, crop types, topography, weather patterns, and water resources.

Remote Sensing: Utilize satellite imagery or aerial photography for up-to-date and comprehensive spatial data.
Field Data: Collect ground-truth data through field surveys, sensor readings, and other on-site measurements.
3. Data Preparation and Integration
Data Cleaning: Ensure that the collected data is accurate, complete, and free from errors.
Data Integration: Combine various data sources (e.g., soil maps, weather data) into a unified GIS database. This may involve converting data into compatible formats and aligning different data layers.



4. Spatial Analysis and Modeling
Data Analysis: Use GIS tools to analyze spatial relationships and patterns. This may include soil analysis, crop health monitoring, and water usage analysis.
Modeling: Develop models to simulate agricultural scenarios, predict outcomes, and support decision-making. For example, a model might predict crop yield based on soil and weather data.
5. Map Creation and Visualization
Map Design: Create maps that visually represent the analyzed data. These maps can show various aspects such as soil fertility, crop distribution, and irrigation needs.
Visualization Tools: Use GIS visualization tools to present data in a clear and interpretable manner. This may include thematic maps, charts, and graphs.

6. Decision Support and Implementation
Decision-Making: Use the insights gained from GIS analysis to make informed decisions. This could involve selecting the best planting locations, optimizing irrigation schedules, or adjusting fertilization practices.

Implementation: Apply the GIS-based recommendations in the field. This might involve adjusting farm operations or implementing new practices based on the GIS data.
7. Monitoring and Evaluation
Monitor Outcomes: Continuously monitor the results of the implemented strategies. This includes tracking changes in crop health, yield, and resource usage.
Evaluate Effectiveness: Assess the effectiveness of GIS-based decisions and make adjustments as needed. Evaluate whether the goals set at the beginning are being met and refine the approach based on the outcomes.
8. Feedback and Improvement
Collect Feedback: Gather feedback from users (farmers, agronomists) on the GIS tools and processes. Identify any issues or areas for improvement.
Update Data and Methods: Regularly update the data and refine GIS methods based on new information, technological advancements, and evolving agricultural practices.
9. Documentation and Reporting
Document Processes: Keep detailed records of the GIS processes, methodologies, and outcomes.
Report Results: Prepare reports and presentations to communicate the results and benefits of the GIS implementation to stakeholders and decision-makers.

By following these steps, agricultural professionals can effectively utilize GIS to enhance farming practices, improve efficiency, and achieve better outcomes in their agricultural operations.

Skill Set (Agron) 17: Technique of using GPS Technology

Objectives:

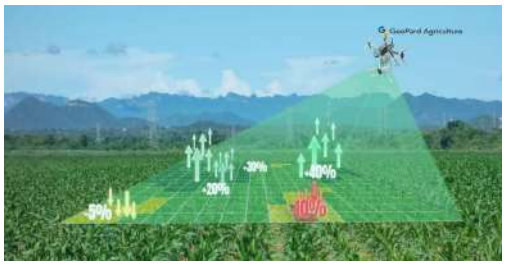
To create farm maps with precise acreage for field areas, road locations and distances between points of interest.

Procedure:

GPS can be used in agriculture in the following ways:

1. Precision Farming

Field Mapping: GPS is used to create accurate maps of fields, including boundaries, topography, and soil types. These maps help in planning and managing farming activities with greater precision.



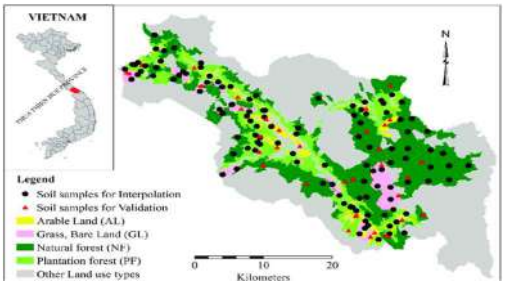
Variable Rate Application: GPS enables the application of inputs (such as seeds, fertilizers, and pesticides) at variable rates based on the specific needs of different parts of a field. This ensures that resources are used efficiently and reduces waste.

2. Auto-Steering Systems

- Tractor Guidance: GPS technology supports auto-steering systems in tractors and other machinery. This technology helps vehicles follow precise paths, reducing overlap and gaps, which enhances field coverage and reduces input costs.
- Reduced Operator Fatigue: Automated steering reduces the need for manual control, minimizing operator fatigue and allowing for more consistent and accurate operations.

3. Yield Mapping

- Yield Monitoring: GPS systems integrated with yield monitors on harvesters track crop yield in real-time as the crop is harvested. This data is recorded and mapped, helping farmers analyze yield variability across fields and make informed decisions for future planting and management.



4. Field Navigation and Management

Efficient Navigation: GPS provides precise navigation for equipment, reducing the time spent navigating fields and improving the efficiency of field operations such as planting, harvesting, and spraying.

Field Boundary Marking: GPS helps in accurately marking field boundaries, preventing accidental overlap with neighboring fields and ensuring proper land use.

5. Irrigation Management

Precision Irrigation: GPS technology is used in conjunction with irrigation systems to optimize water application. It allows for precise control of irrigation zones and schedules based on soil moisture data and crop needs.

Avoiding Runoff: Accurate GPS mapping helps in designing irrigation systems that minimize water runoff and optimize water use efficiency.

6. Soil Sampling and Analysis

- Targeted Soil Sampling: GPS guides soil sampling equipment to specific locations within a field. This allows for targeted soil analysis and helps in creating detailed soil maps, which are essential for making informed decisions about soil management and fertilization.

7. Monitoring and Surveillance
   - Tracking Equipment: GPS allows for real-time tracking of farm equipment and vehicles, improving fleet management and ensuring that machinery is used efficiently.
   - Field Surveillance: GPS can be combined with other technologies such as drones and sensors for monitoring crop health, pest infestations, and other field conditions.
8. Farm Planning and Management
   - Land Use Planning: GPS data helps in planning and managing land use, including crop rotation, field layout, and infrastructure placement.
   - Record Keeping: GPS technology aids in maintaining detailed records of farming activities, which is useful for analyzing trends, planning future operations, and meeting regulatory requirements.
9. Research and Development
   - Field Trials: Researchers use GPS technology to conduct field trials and experiments with precision, helping to develop new crop varieties, farming practices, and technologies.
10. Environmental Monitoring
    - Sustainability: GPS helps in monitoring environmental impacts such as soil erosion, water usage, and biodiversity, supporting sustainable farming practices.

Skill Set (Agron) 18: Technique of using Remote Sensing

Objectives:

To assist in the analysis of land use and land cover for various applications like natural resource management, urban planning, and tracking land use changes over time.

Procedure:

GPS can be used in agriculture in the following ways:

1. Crop Health Monitoring
   - Early Detection: Remote sensing technologies, such as satellites and drones equipped with multispectral and hyperspectral sensors, can detect signs of crop stress, diseases, and pests before they are visible to the naked eye.
   - Vegetation Indices: By analyzing vegetation indices like NDVI (Normalized Difference Vegetation Index), remote sensing can assess plant health, biomass, and chlorophyll content.

2. Precision Farming
   - Field Mapping: Remote sensing creates detailed maps of crops, soil, and field conditions, enabling precision farming practices. These maps help in understanding variability within fields and applying inputs (e.g., water, fertilizers) more accurately.
   - Variable Rate Application: Data from remote sensing can guide variable rate application of fertilizers, pesticides, and water, optimizing input usage and reducing waste.

3. Soil Analysis
   - Soil Properties: Remote sensing can provide information on soil moisture, texture, and composition. This data helps in creating soil maps and making informed decisions about soil management and crop selection.
   - Soil Moisture Monitoring: Satellite data can track soil moisture levels over time, helping farmers manage irrigation more effectively.

4. Yield Prediction and Assessment
   - Yield Estimation: Remote sensing helps estimate crop yields by analyzing growth patterns, plant health, and other factors. This allows for better forecasting and planning.
   - Harvest Monitoring: During the harvest season, remote sensing can assess crop readiness and monitor harvesting progress.

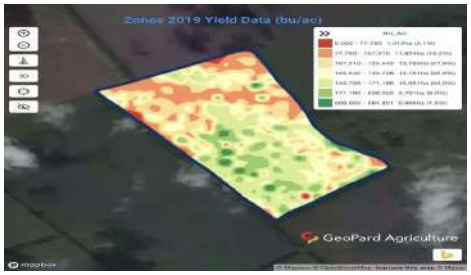
5. Irrigation Management
   - Water Stress Detection: Remote sensing identifies areas experiencing water stress or over-irrigation, allowing for more efficient water use and better irrigation management.
   - Irrigation Scheduling: Data from remote sensing can help optimize irrigation schedules based on crop needs and soil moisture levels.

6. Land Use and Crop Mapping
   - Crop Classification: Remote sensing can classify different types of crops and land use within a region. This helps in monitoring crop rotation and managing land resources effectively.
   - Mapping and Monitoring: Creating up-to-date maps of field conditions, crop types, and land use changes helps in effective farm planning and management.

7. Pest and Disease Management
   - Pest Detection: Remote sensing can detect changes in crop conditions that may indicate pest infestations, allowing for timely intervention.
   - Disease Monitoring: Remote sensing helps in identifying areas affected by plant diseases and tracking their spread.

8. Environmental Monitoring
   - Erosion and Runoff: Remote sensing can monitor soil erosion, water runoff, and other environmental impacts related to agricultural practices.
   - Sustainability: Tracking changes in land use, vegetation cover, and ecosystem health supports sustainable farming practices and environmental conservation.

9. Disaster Response
   - Damage Assessment: After natural disasters like floods, droughts, or storms, remote sensing provides rapid assessments of crop damage and helps in recovery planning.
   - Risk Management: Monitoring environmental conditions and potential hazards helps in managing risks and mitigating the impact of adverse events.



10. Research and Development
   - Field Experiments: Researchers use remote sensing to monitor and evaluate experimental plots, new crop varieties, and innovative farming practices.

- Data Collection: Remote sensing provides large-scale and consistent data for agricultural research and development.

Tools and Technologies

- Satellites: Provide large-area coverage and frequent revisits, useful for regional and global monitoring.
- Drones: Offer high-resolution imagery and flexibility for detailed field-level observations.
- Aerial Imagery: Captures detailed images from aircraft, useful for various agricultural applications.

Skill Set (CIB) 1: Plant genomic DNA isolation

Procedure:

The whole procedure and materials required to acquire the skill set is shown diagrammatically as below:

Plant sample

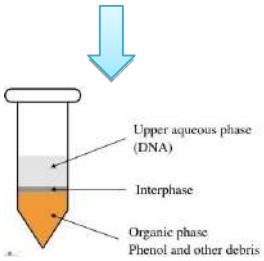
Step 1: Plant sample collection (Meristematic tissues (new leaves)

Step 2: Plant sample grinding into fine powder in liquid Nitrogen (LN_2) using aseptic mortarand pestle.

Step 3: The fine powdered material transferred to 800 µL of pre-warmed CTAB buffer and incubate for 60 minutes with occasional stirring at 65˚ C in water bath.

Step 4: After 1 hour of incubation, the DNA samples will be place at room temperature for 5-6 minutes for cooling and an equal volume (800 µL) of chloroform: isoamyl (24:1) added to the centrifuge tube and gently mixed by vortexing the tubes.

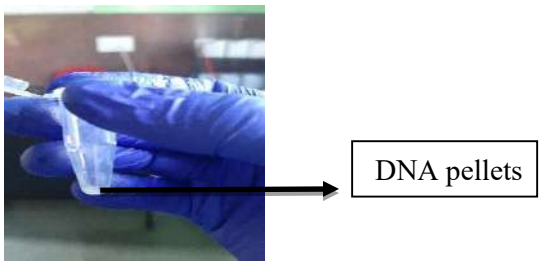
Step 5: The DNA samples were centrifuged at 13,000 rpm for 15 minutes on 25˚ C.



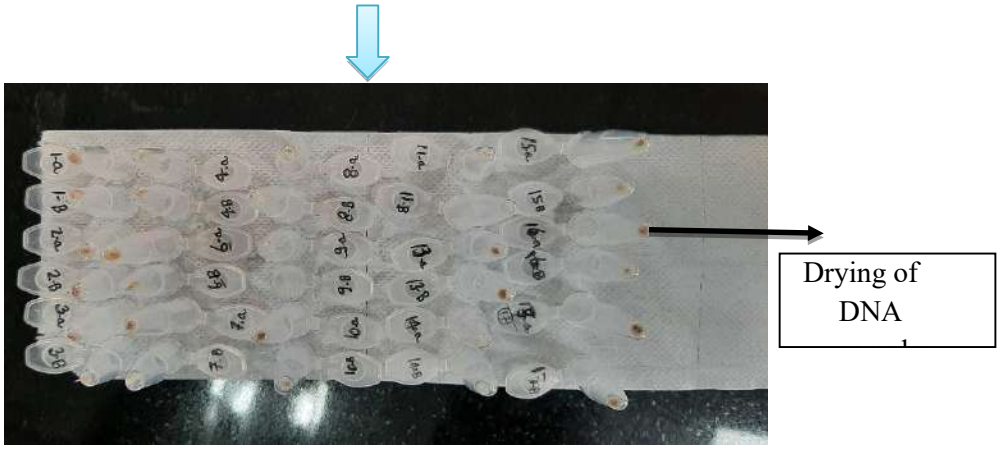
Step 6: After centrifuge three phases will be formed namely, aqueous phase, middle phase and organic phase. Only aqueous phase will be transferred in a pre-sterilized other centrifuge tube.

Step 7: The plant genomic DNA was precipitated with the addition of an equal volume of chilledisopropanol mixed gently and stored at -20°C overnight.

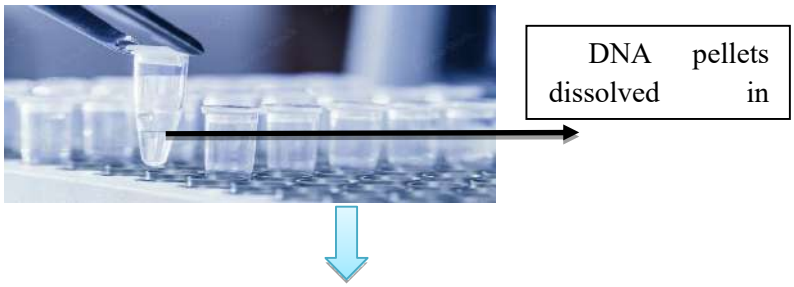
Step 8: Next day the DNA samples were centrifuged at 13000 rpm for 10 minutes at 4˚C. temperature.



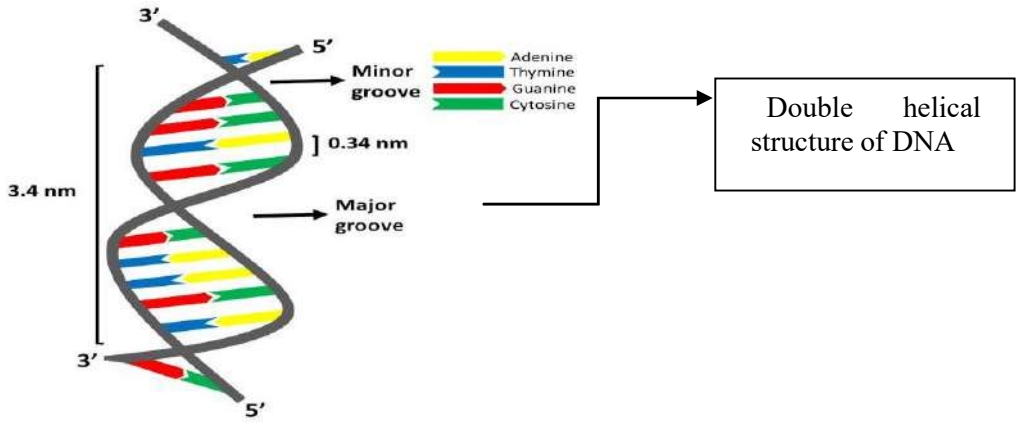
Step 9: After the centrifuge the isopropanol containing supernatant was discarded and the DNA pellets were obtained from the bottom of centrifuge tube.



Step 10: The DNA samples will be washed with 70% ethanol twice to remove the impurities and air dried until the ethanol evaporated from the DNA containing centrifuge tubes.



Step 11: After drying DNA pellets were dissolved in 50 µL ddH_2O and stored at 4°C. temp.



Skill Set (CIB)-2: Emasculation and hybridization-Reproduction and Pollination techniques

A. Emasculation and hybridization techniques

Materials required: 1. Magnifying glass; 2. Pointed forceps, 3. Scissors, 4. Needle, 5. Sharp pointer, 6. Brush, 7. U Clips, 8. Muslin Cloth Bag, 9. Butter Bag, 10. Crossing Tags, 11. Aluminium tags, 12. Pencil, eraser, and pen, 13. Sample bag, 14. Ethanol, 15. Thread Field Book, 16. Waxy thread

Emasculation: Removal of stamens or anthers or the killing of the pollen grains of a flowerwithout affecting in any way the female reproductive organs.

Various methods of emasculation

i) Hand Emasculation or Forceps or Scissor Method: Used in those plants which have large flowers. In this method the corolla of the selected flowers is opened and the anthers carefully removed with the help of fine-tip forceps.

ii) Hot Water Treatment: Usually done in small flowers. It is done by dipping the flowers in hot water for certain duration (1-10 minutes) of time. Is based on the fact that gynoecia can withstand the hot temperature at which the anthers are killed. In this method an equipment is used which is placed on a simple heavy stand.

iii) Cold Water Treatment: Kills pollen grains without damaging the gynoecium. In rice 0-6°C temperature is maintained to kill the pollen grains. This method is less effective than hot water treatment.

iv) Alcohol Treatment Method: Duration of treatment is an important factor since a very short duration is required failing which even the gynoecium may be damaged. Flowers or inflorescences are immersed in alcohol of a suitable concentration for a brief period. Eg. In alfalfa, treatment of even 10 seconds with 57 % alcohol is sufficient to kill the pollen grains.

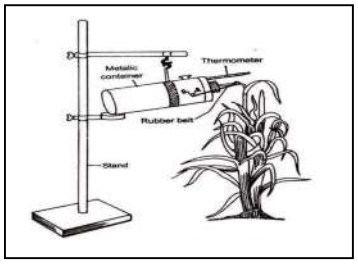
v) Suction Method: The amount of pressure is applied in such a way that only anthers are sucked out and other parts of the flower like gynoecium remain intact. However,in this method 10-15% self-pollination takes place.

vi) Male Sterility or Self-incompatibility Method: The emasculation option can be eliminated by the use of male-sterile plants, in some self-pollinated plants for example, Sorghum, Onion,

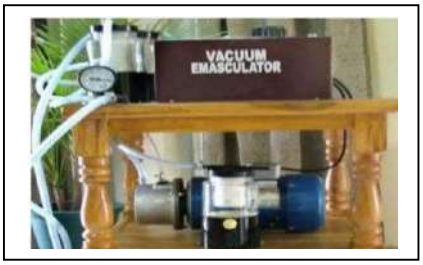
Barley, etc. anthers are sterile and do not produce any viable pollens. Similarly, self-incompatibility may also be used to avoid emasculation.

vii) Chemical Gametocides: 2, 4-D, naphthalene acetic acid (NAA), maleic-hydrazide (MA), tribenzoic acid.

Hand emasculation



Hot water treatment



Vacuum emasculator

Selection of Parents

Selfing of parents or artificial self-pollination for inducing homozygosity for eliminating the undesirable characters and obtaining inbreeds.

Emasculation of flowers

Bagging of Emasculated Plants

Tagging of emasculated with proper date of emasculation and pollination, name of the parents

Pollination of emasculated flowers: Fertile and viable pollens from the male parent are placed on the receptive stigma of emasculated flowers to bring about fertilization.

Harvesting of the crossed seeds and stored the F1 seeds with original tags

Raising of F1 seeds

Skill Set (CIB) 3: Seed purity test (physical, genetic, viability, germination etc.)

SEED PURITY ANALYSIS

Procedure:

1. The work board, sample, and purity dishes should be cleaned before separation
2. Place the working sample and spread it on the purity workboard.
3. Draw the working sample into a thin line with the help of a spatula or forceps, and examine each particle individually. The seeds are examined based on their shape, size,colour, gloss, surface texture and, based on their appearance when placed under the light
4. Identify and separate the impurities such as other crop seeds, weed seeds and inert matter. The impurities are placed separately in purity dishes whereas the pure seeds are retained on the workboard.
5. If the sample contains seeds enclosed in fruits other than those indicated in pure seed, they should be separated. The empty fruit/appendages are then classified as inert matter.
6. The pure seed is collected in the sample pan.
7. The sample is examined under magnification for further separation into different components (other crop seed, weed seed and inert matter).
8. The other crop seed, weed seed, inert matter are identified after separation and their names recorded. The kind of inert matter present in the sample should also be identified and recorded.
9. Each component is weighed in grams separately- pure seed, other crop seed, weed seed and inert matter to the number of decimal places shown in the following table

S. No.	Weight of working sample (g)	Number of decimal place required	Example
1	Less than 1	4	0.9025
2	1 to 9.990	3	9.025
3	10 to 99.99	2	90.25
4	100 to 999.9	1	902.5
5	1000 or more	0	9025

10. The percentage by weight of each component is calculated up to one decimal place only. The percentage is based on the sum of the weight of all four components. If the percentage of any component is less than 0.05% it is recorded as 'Trace'.

Reporting results: The percentage of all components must total 100. When reporting the results, the kind of inert matter and the Latin names of the crop seed and weed seed found inthe sample should be mentioned.

Seed germination test:

Germination is defined as the emergence and development from the seed embryo, of those essential structures, for the kind of seed in question, indicates its ability to produce a normalplant under favourable conditions.

Principles:

Germination tests shall be conducted with a pure seed fraction. A minimum of 400 seeds are required in four replicates of 100 seeds each or 8 replicates of 50 seeds each or 16 replicatesof 25 seeds each depending on the size of the seed and size of containers of substrate.

The test is conducted under favourable conditions of moisture, temperature, suitable substratum, and light if necessary. No pretreatment to the seed is given except for thoserecommended by ISTA.

Materials required:

Substratum

The substratum serves as a moisture reservoir and provides a surface or medium for which the seeds can germinate and the seedlings grow. The commonly used substrates are sand, germination paper, and soil.

Sand

Size of sand particle

Sand particles should not be too large or too small. The sand particles should pass through a 0.80 mm sieve and retained by a 0.05mm sieve.

Toxicity

Sand should not have any toxic material or any pathogen. If there is a presence of any pathogen found, then the sand should be sterilized in an autoclave.

Germination tray

When we use the sand, germination trays are used to carry out the test. The normal size of the tray is 22.5 x 22.5 x 4 cm. The tray may be either zinc or stainless steel.

Method of seed placement

Seed in sand(S)

Seeds are planted in a uniform layer of moist sand and then covered to a depth of 1 to 2 cmwith sand. Seeds are pressed into the surface of the sand.

Spacing

We must give equal spacing on all sides to facilitate the normal growth of seedlings and to avoidthe entangling of seeds and the spread of disease. Spacing should be 1-5 times the width or diameter of the seed.

Water

The amount of water to be added to the sand will depend on the size of the seed. For cereals, except maize, the sand can be moistened to 50% of its water-holding capacity. For large seeded legumes and maize sand is moistened to 60% water holding capacity.

1. Paper

The most widely used paper substrates are filter paper, blotter, or towel (kraft paper). It should have capillary movement of water, in at vertical direction (30 mm rise / min.). It should be free from toxic substances and free from fungi or bacteria. It should hold sufficient moisture during the period of the test. The texture should be such that the roots of germinating seedlings will grow on and not into the paper.

Methods:

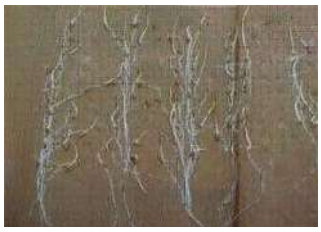
Top of paper

Seeds are placed on one or more layers of moist filter paper or blotter paper in Petri plates. These Petri plates are covered with lid and placed inside the germination cabinet. This is suitable for those seeds which require light.

Between paper:

The seeds are germinated between two layers of paper. The seeds are placed between two layers of paper and rolled in towels. The rolled towels are placed in the germinator in an upright position.

Petri plate Method



Seeds germinated on paper

Roll towel method

Germination apparatus:

Germination cabinet / Germination room

This is called chamber where in temperature and relative humidity are controlled. We can maintain the temperature, relative humidity and light required for different crops.

Seed germinator

It works with the same principle as that of germinator. This is a modified chamber of a larger one and the worker can enter into it and evaluate the seedlings. Provisions are made to maintain the temperature and relative humidity. This is used widely in practice.

Seed germinator

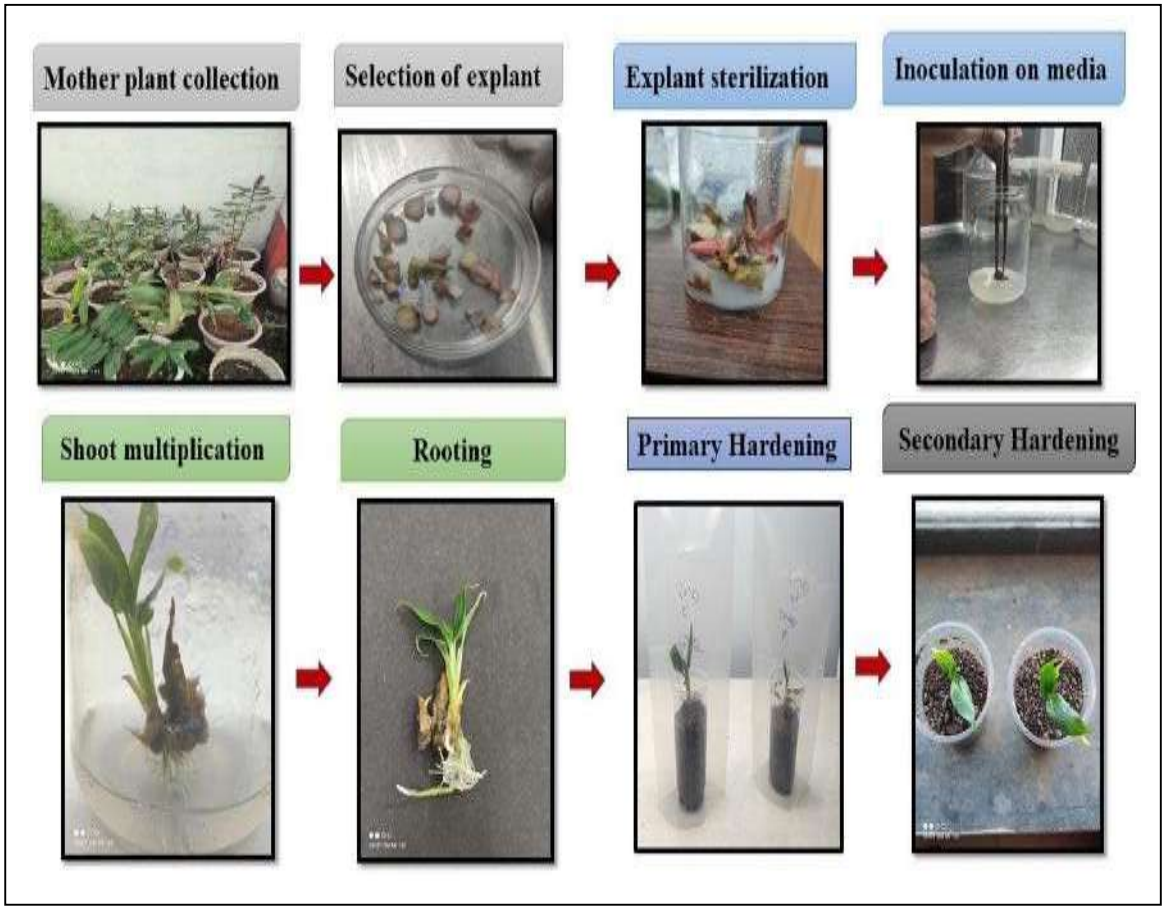
Skill Set (CIB) 4: Tissue culture techniques for micro-propagation of crops

Procedure:

As an example of the technique, the production of *in vitro* regeneration technique for Red Ginger (*Hedychium rubrum*) for North Eastern India is shown diagrammatically as below:

Steps required:

i) Mother plant collection, ii) Selection of explants, iii) Explant sterilization, iv) Inoculation on media, v) Shoot multiplication, vi) Rooting, vii) Primary hardening, viii) Secondary hardening, ix) Transplant to the field etc.,



Skill Set (CIB) 5: Wet and dry laboratory skills in molecular biology/Genetics

Task 1: DNA extraction, PCR, Gel electrophoresis

Activity 1: DNA extraction using CTAB methods

Objective: To extract good quantity and quality DNA

Material required:

a. Plant materials: Fresh, young and tender leaves (A minimum of ten replicates to be taken for each variety).

Reagents required:

a. 100 mM Tris–HCl (pH 8),
b. 1.4 M Sodium Chloride (NaCl),
c. 20 mM-Ethylenediaminetetraacetic acid (EDTA) (pH 8),
d. 2% (w/v) Cetyl trimethylammonium bromide (CTAB)
e. Chloroform-isoamyl alcohol (24:1)
f. Isopropanol, 70% ethanol
g. TE buffer (pH 8): 10 mM Tris–HCl, 1 mM EDTA
h. 0.5× Tris/Borate/EDTA (TBE) (10× stock contained 1 M Tris, 0.8 M boric acid, 0.5 M EDTA)
i. Agarose (molecular grade)

Procedure:

1. Preheat the extraction buffer containing 100 mM Tris–HCl (pH 8), 1.4 M NaCl, 20 mMEDTA (pH 8), 2% (w/v) CTAB in a water bath at 60°C for about 15 minutes.
2. Submerge 1 g of plant tissue in 5 ml of absolute alcohol for 5 minutes and allow the alcohol to evaporate.
3. Grind the tissue in presence of liquid nitrogen by using a pre-chilled mortar and pestle and pre-warmed extraction buffer.
4. Transfer the ground material into 2 ml centrifuge tubes and incubate in water bath at 60°C for 1 hour.
5. Centrifuge the tubes at 10,000 rpm for 10 minutes at 4°C and collect the supernatant in 1.5 ml centrifuge tube using wide bored tip.
6. To the supernatant add equal volume of chloroform: isoamyl alcohol (24:1) and mix by inversion for 15 minutes.
7. Centrifuge the tubes at 10,000 rpm for 10 minutes at 4°C and collect the supernatant in 1.5 ml centrifuge tube.
8. Again add equal volume of chloroform: isoamyl alcohol (24:1) to the supernatant and mix by inversion for 15 minutes.
9. Centrifuge the tubes at 10,000 rpm for 10 minutes at 4°C and collect the supernatant.
10. To the supernatant add twice the volume of chilled isopropanol to precipitate the DNA and incubate it at -20°C for 30 minutes.
11. Centrifuge the tubes at 10,000 rpm for 10 minutes at 4°C and collect the pellet.
12. Wash the pellet 2–3 times with 70% ethanol and air dry the pellet in room temperature.
13. Add 50–100 µl of TE buffer to dissolve the DNA.
14. Store at -20°C for further use.

Fig. 1: Plant Sample

Fig. 2: Grinding the plant tissue with liquid nitrogen

Fig.3: Ground material with extraction buffer

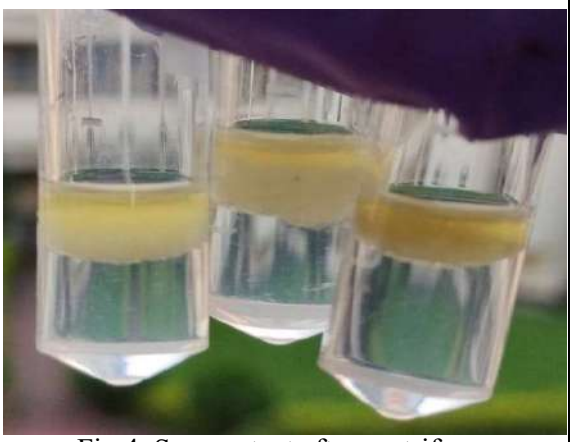


Fig.4: Supernatant after centrifuge

Fig.5: DNA precipitate

Fig. 6: DNA pellet

Activity 2: Operation and handling of PCR machine

Objective: To detect and identify gene sequences

Pre-operation Checks:

1. Inspection

- Inspect the PCR machine for cleanliness and integrity before use.
- Ensure that the thermal cycler and control panel are functional and calibrated.

- Check that the sample wells are clean and free of any residue.

2. Preparation

- Clean the sample wells with a suitable disinfectant.
- Prepare the PCR reagents and samples according to the specified protocol.
- Load the samples into the PCR machine and secure the lid.

3. Operation

1 Setting the Controls

- Turn on the PCR machine and set the desired thermal cycling parameters according to the procedure.
- Start the PCR process and monitor the thermal cycling to ensure proper amplification.
- Adjust the thermal cycling parameters if necessary to achieve the desired results.

4. Safety Precautions

- Wear appropriate personal protective equipment (PPE) when handling the PCR machine and samples.
- Avoid opening the machine lid while the PCR process is in progress to prevent contamination.
- Follow all safety protocols to prevent contamination or accidents.

Post-operation

Shutting Down

- Turn off the PCR machine and remove the samples from the wells.
- Clean the sample wells and any used reagents with a suitable disinfectant. Document any deviations in thermal cycling parameters or process conditions.

Cleaning and Maintenance

- Regularly clean the sample wells and control panel with a suitable disinfectant.
- Inspect the thermal cycler for any signs of wear or damage and repair or replace components as necessary.
- Calibrate the thermal cycling parameters periodically to ensure accuracy.
- Document all cleaning and maintenance activities in the PCR machine log.

Reagents for PCR

Components of PCR Cocktail preparation

Components	Concentration
Primer	1µl
Water	5.75µl
Buffer	1.0ul
dNTPs	0.5 ul
Taq polymerase	0.25 ul
Total	10 ul

The concentration value will be multiplied by the number of wells based on the availability of the sample size.

Protocol for PCR analysis

1. A PCR plate is taken and labeled for each genomic DNA.

2. 2 µl of template DNA is added into each well of PCR plate.

3. PCR reaction cocktails are prepared in the cocktail tube for the required for number of reactions.

4. 18 µl of the PCR reaction mixture needs to be added into each well, which was already loaded with 2µl of template DNA making the final volume 20 µl.

5. PCR plate needs to be covered and centrifuged @ 500 rpm for 1 minute to bring down the contents to the bottom of the wells.

6. The PCR reaction is performed in a Programmable Thermo Cycler.

Activity 3: Demonstration of gel electrophoresis techniques.
Objective: To resolve DNA fragments based on their molecular weight

Materials required: TAE buffer, Agarose gel (1% in TAE buffer), loading dye, casting tray, gel electrophoresis unit, trans illuminator, ethidium bromide solution, distilled water.

Principle:

Agarose gel electrophoresis is a routinely used method for separating proteins, DNA, or RNA. Nucleic acid molecules are size separated by the aid of an electric field where negatively charged molecules migrate toward an anode (positive) pole. The migration flow is determined solely by the molecular weight where small-weight molecules migrate faster than larger ones. To visualize nucleic acid molecules in agarose gels, ethidium bromide or SYBR Green are commonly used dyes. Illumination of the agarose gels with 300-nm UV light (under transilluminator) is subsequently used for visualizing the stained nucleic acids.

Procedure:

1. Prepare a 1 % solution of agarose by melting 1 g of agarose in 100 mL of 1X TAE buffer in a microwave for approximately 2 min.
2. Allow to cool for a couple of minutes then add 2.5 µl of ethidium bromide, and stir to mix.
3. Cast a gel using a supplied tray and comb. Allow the gel to set for a minimum of 20 min at room temperature on a flat surface.
4. Load the following into separate wells - 10 µL 1kb ladder, 5 µL sample + 1µL 6x Loading dye.
5. Run the gel for 30 min at 100 V.
6. Expose the gel to UV light (under a transilluminator) and photograph.
7. Confirm DNA quality, the presence of a highly resolved high molecular weight band indicates good quality DNA, presence of a smeared band indicates DNA degradation.

Precautions:

- ❖ The temperature of the agarose solution should be around 55-65° C at the time of casting. Avoid pouring it very hot or cold.
- ❖ Ethidium bromide is a mutagen and should be handled as a hazardous chemical (Always wear gloves while handling).

Skill Set (CIB) 6: Slide preparation for cytological studies

Activity 1: Preparation of stains and fixatives like Carnoy's solution, Farmer's solution, Aceto-carmine, *etc.*

Objective: To prepare various stains and fixatives such as Carnoy's solution, Farmer's solution, and Acetocarmine. These chemical solutions are essential in biological studies, particularly in cytology and histology, for preserving specimens and enhancing the contrast of microscopic structures, enabling clear observation and analysis of cellular and tissue samples.

Procedure:

1. Preparation of Carnoy's Solution:

- **Materials Needed:**
  - Absolute Ethanol: 60 mL
  - Chloroform: 30 mL
  - Glacial Acetic Acid: 10 mL

- **Steps:**
    1. Measure 60 mL of absolute ethanol and pour it into a clean glass container.
    2. Add 30 mL of chloroform to the ethanol, mixing gently.
    3. Finally, add 10 mL of glacial acetic acid to the mixture.
    4. Stir the solution gently to ensure thorough mixing.
    5. Store the prepared Carnoy's solution in a tightly sealed container, protected from light.

2. Preparation of Farmer's Solution:

- **Materials Needed:**
    - 95% Ethanol: 90 mL
    - Glacial Acetic Acid: 10 mL
- **Steps:**
    1. Measure 90 mL of 95% ethanol and pour it into a clean container.
    2. Add 10 mL of glacial acetic acid to the ethanol.
    3. Mix the solution thoroughly to ensure complete integration.
    4. Store the Farmer's solution in a sealed container, away from direct sunlight.

3. Preparation of Acetocarmine Stain:

- **Materials Needed:**
    - Carmine Powder: 1g
    - Glacial Acetic Acid: 45 mL
    - Distilled Water: 55 mL
- **Steps:**
    1. Weigh 1g of carmine powder and place it in a small beaker.
    2. Add 45 mL of glacial acetic acid to the carmine powder.
    3. Heat the mixture gently in a water bath, stirring continuously until the carmine dissolves completely.
    4. Once dissolved, add 55 mL of distilled water to the solution.
    5. Filter the solution to remove any undissolved particles.
    6. Store the Acetocarmine stain in a dark glass bottle, tightly sealed, and labeled appropriately.

Activity 2: Preparation of samples to study cell division-skills like selection of right sample and cutting and smearing of samples carefully on the slides

Objective:

The objective of this experiment is to prepare and study cell samples under a microscope to observe the process of cell division. This involves selecting appropriate biological samples that are likely to be in various stages of cell division, carefully cutting or isolating the relevant tissue, and properly preparing slides by smearing the samples for microscopic observation. The goal is to ensure that the prepared slides contain cells in different phases of the cell cycle, including mitosis, so that they can be accurately analyzed under a microscope.

Procedure:

1. **Selection of the Sample:**
    - **Choose an Appropriate Sample:** Select a biological specimen where active cell division is expected to occur. Common examples include the root tips of plants (e.g., onion root tips), embryonic tissues, or certain types of animal cells known for rapid division.

- **Identify the Area of Active Division:** In the selected specimen, identify the regions that are likely to show active cell division. For example, in a plant root, the meristematic region near the tip is ideal.

2. **Preparation of the Sample:**
    - **Isolate the Sample:** Using a sharp scalpel or scissors, carefully cut a small piece of the selected tissue (e.g., a 1-2 mm section from the root tip).
    - **Fixation (Optional):** If needed, fix the sample in a suitable fixative (e.g., ethanol or formaldehyde) to preserve cell structure and prevent degradation.
    - **Staining:** Stain the sample with a suitable stain, such as acetocarmine or iodine, to enhance the visibility of chromosomes and cell structures.

3. **Slide Preparation:**
    - **Smearing the Sample:**
        a) Place the sample on a clean microscope slide.
        b) Add a drop of water or stain to the sample.
        c) Gently tease apart or crush the sample using a dissecting needle or forceps to spread out the cells.
        d) If using a root tip, you may gently tap or squash the sample with a coverslip to spread the cells into a single layer.
    - **Covering the Sample:** Carefully place a coverslip over the sample, avoiding air bubbles.
    - **Sealing the Coverslip (Optional):** If the sample needs to be observed for an extended period, you may seal the edges of the coverslip with nail polish or another sealant.
4. **Microscopic Observation:**
    - **Adjust the Microscope:** Place the slide on the microscope stage and start with the lowest magnification.
    - **Focus and Observe:** Gradually increase the magnification and focus on the cells. Identify cells in different stages of cell division (prophase, metaphase, anaphase, telophase) and observe their characteristics.
    - **Record Observations:** Draw or photograph the observed stages of cell division for analysis and comparison.
5. **Cleanup:**
    - **Clean the Slides and Equipment:** After observation, clean the slides, coverslips, and any other equipment used during the experiment.
    - **Dispose of Waste Properly:** Dispose of biological waste and chemical stains according to your laboratory's safety protocols.

Task 3: Handling of Microscope

Activity 1: Handling and operation of microscope
Objective: To study structure and working of a microscope

Microscope: A microscope may be defined as an optical instrument, consisting of a lens, or combination of lenses, for making enlarged or magnified images of minute objects. Microscope was invented by Zaccharias Jansen in 1590 and it was then improved by Anton Van Leeuwenhoek in 1676.

Kinds of microscope:

a) Simple microscope: A simple microscope consists of only one convex lens or magnifying glass held in a frame, usually adjustable, and often provided with a stand for conveniently holding object to be viewed and a mirror for reflecting the light.

b) Compound microscope: A compound microscope differs from a simple microscope in having two sets of lenses, one known as the objective and the other as the eyepiece, mounted in a holder commonly known as a body tube. The lens system nearest the specimen, called the objective, which magnifies the specimen a definite number of times. The second lens system, called the eyepiece, further magnifies the image formed by the objective. The image seen by the eye has a magnification equal to the product of the magnifications of the two systems. Compound microscopes give much greater magnifications than simple microscopes and are necessary for viewing and examining minute objects such as bacteria. It has two parts:

I. Mechanical parts

- **Base:** It is a horse-shoe shaped structure and provides a stable support for the microscope.
- **Pillar**: It is small vertical projection from the base.
- **Arm**: It is usually curved and used for handling the microscope.
- **Inclination joint**: At this joint the arm is attached to pillar. The microscope can be tilted at this joint.
- **Stage**: It is usually a rectangular plate attached to the lower end of the arm. It is used for keeping an object to be magnified. It has a hole in the centre for the light rays to pass.
- **Clips**: There are two clips attached to the stage which are used for holding the slide in position.
- **Diaphragm**: It is attached to the base of the stage and regulates the amount of light entering into the microscope. Disc and iris-diaphragm are two types of it.
- **Body tube:** It is a tubular hollow part attached to the upper part of the arm. It can be moved up nd down with the help of screws.
- **Nose piece**: It is a circular metallic structure attached below the body tube. Three different objective lenses can be fitted into it.
- **Coarse adjustment screw**: It is a bigger-sized screw used for gross focusing of an object.
- **Fine adjustment screw**: It is a smaller-sized screw used for fine focusing the object.

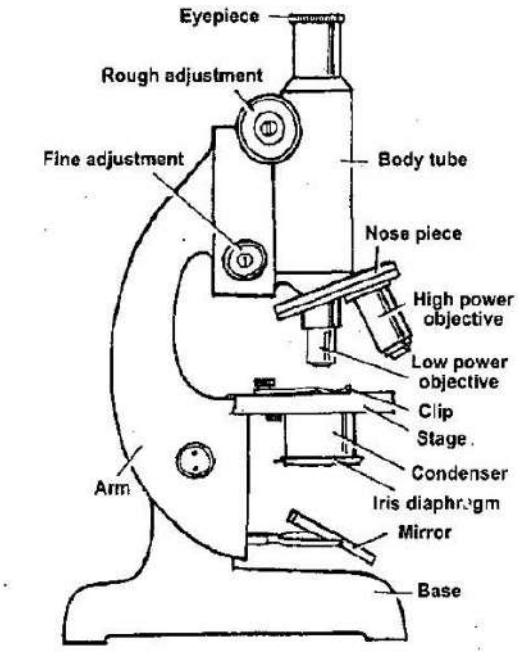
II. Optical parts

- Mirror: It is attached to the lower end of the arm. It is used for reflecting light rays into the microscope.
- Objective lens: They are attached to the nosepiece. There are three lenses -10X, 40X or 45X and 100X.
- Eyepiece lens: It is a lens fitted at the top of the body tube through which the magnified image of the object is seen. It is of magnification 10X or 15X.

Operation of the microscope

- First of all, adjust the mirror so that sufficient light enters into the microscope.
- Keep a clean prepared slide on the centre of the stage.
- Used clips to fix the slide on the stage.

- Move the coarse adjustment screw to bring in focus.
- Focusing should be made sharp by the use of fine adjustment screw.
- Low magnification lens- 10X or 15X should be used for initial focusing
- Rotate the nose so as to replace it with 40 X or 45X
- Finally adjust the focus with the help of fine adjustment screw to the sharp focus.



Activity 2: Cleaning and maintenance of microscope
Objective: To ensure proper care and maintenance of the microscope
Procedure:

1. The microscope should be kept in case or properly covered with when it is not in use.
2. The microscope should be carried by holding the arm of the microscope stand with one hand and the other hand should be placed under the base.
3. Cleaning of microscope:
    a. Cleaning of optical parts: The mirror, ocular, objectives, and condenser should be wiped free off dirt with a piece of clean lens paper or soft cotton. The dirt should not be grinded into the lenses but the dust should be wiped off lightly, and then polished afterward. Attempts should not be made to apart the ocular or objectives. The lenses should not be touched with the fingers. Lenses should be cleaned with lens paper.
    b. Cleaning of body of the microscope: The body of the microscope should be cleaned with soft cloth before starting the work as well as the end of the work.
    c. Cleaning of oil immersion objectives: Immediately after use of the oil immersion objective, the excess oil must be wiped off with clean lens paper or cotton. If oil has dried on the lens, it may be removed by wiping with lens paper or cotton moistened with a little xylol.
3. Water and mounting fluid should never be allowed to come in contact with the lens. Film of oil and other chemicals should be removed with distilled water or xylol.
4. Cover slip should be used to protect the front lens from chemical of mounting fluids.
5. Needle or wooden appliances should not be used to clean the lenses.
6. The microscope should not be kept in extreme temperature and humidity.

7. Placing the objectives in position:
   a) Oil immersion objective: The oil immersion lens must be lowered into the oil over the smear until it almost but not quite touches the slide.
   b) High power objective: The high power objective should also be lowered as close to the slide as possible without actually touching the preparation.
   c) The low power objective: The low power objective should be lowered to about one quarter inch above the slide.
8. The body tube should never be lowered keeping eyes at the ocular because the objective may be driven down so far as to break the slide or injury the lens.

Skill Set (CIB) 7: Operation of Software for statistical/ genetical /breeding experiments

Activity 1: Operation of software such as OP-STAT, Darwin, and R-software (basic) for breeding and genetical analysis

Objective: To utilize software tools such as OP-STAT, Darwin, and R (basic) to perform breeding and genetic analyses. These tools will be used to analyze and interpret data related to plant or animal breeding experiments, genetic mapping, and statistical analysis. The goal is to ensure accurate and efficient data processing, leading to meaningful insights into genetic variation, heritability, and selection within breeding populations.

Procedure:

1. **Software Installation and Setup:**
   - Install OP-STAT, Darwin, and R software on the computer.
   - Ensure all necessary packages and libraries for genetic and breeding analysis are installed, especially in R.

2. **Data Collection and Preparation:**
   - Gather relevant breeding and genetic data, such as phenotypic measurements, genotypic information, and pedigree records.
   - Organize the data in a format compatible with the software being used, such as CSV files for R or specific formats required by OP-STAT and Darwin.

3. **Data Input:**
   - Import the prepared data into the respective software:
     - **OP-STAT:** Input the data into the OP-STAT interface for basic statistical analysis, including ANOVA, correlation, regression, and mean comparison.
     - **Darwin:** Use Darwin software for genetic diversity analysis, such as Principal Component Analysis (PCA), clustering, and molecular marker data analysis.
     - **R:** Load the data into R using appropriate commands and packages (e.g., read. csv(), data. frame()) for more complex statistical and genetic analysis.

4. **Analysis Execution:**
   OP-STAT:
   - Perform statistical tests such as ANOVA to analyze variance within and between breeding groups.
   - Conduct mean comparisons to identify significant differences between genotypes.

   Darwin:
   - Run PCA to identify patterns of genetic diversity among the populations.
   - Perform clustering analysis to group genotypes based on genetic similarity.

R Software:

- Use basic R commands and functions to perform statistical analyses (e.g., lm(), anova()).
- Apply genetic analysis packages like qtl, adegenet, or hierfstat to conduct QTL mapping, diversity analysis, or other relevant genetic analyses.

5. **Result Interpretation:**
   Review the output from each software to interpret the results:
   - **OP-STAT:** Interpret statistical outputs to understand breeding performance.
   - **Darwin:** Analyze genetic diversity and structure based on PCA and clustering results.
   - **R:** Interpret statistical models, genetic maps, or diversity indices generated.
6. **Documentation and Reporting:**
   - Document the procedures, settings, and parameters used in each software.
   - Compile the results into a comprehensive report, including statistical outputs, graphs, and interpretations.
   - Discuss the implications of the findings for breeding strategies and genetic improvement.
7. **Validation and Verification:**
   - Cross-check the results obtained from different software to ensure consistency and accuracy.
   - Validate the findings against known benchmarks or previous studies to confirm their reliability.
8. **Data Backup and Software Maintenance:**
   - Save all analysis files, scripts, and data securely.
   - Regularly update the software and its packages to ensure optimal performance for future analyses.

Skill Set (CIB) 8: Maintenance and multiplication of Nucleus and Breeder seed

Activity 1: Rouging in seed production plot

Obective: Selective removal of undesirable plants from a seed crop based on visual field inspection, to improve one or more quality (genetic purity, disease-free) attributes of the seed lot to be harvested

Significance of rouging

- Rouging: - The selective removal of undesirable plants from a seed crop on the basis of visual field inspection, in order to improve one or more quality (genetic purity, disease-free) attributes of the seed lot to be harvested" (Laverack and Turner 1995).
- Removal of noxious weeds (wild oats in wheat, and Argemone mexicana in Brassica species) that are liable to multiply with the seed crop, thus affecting future generations, may be regarded as part of rouging.
- Rouging at all stages of the crop in the field is an essential requirement to maintain the variety purity as it was at the time of release/notification.
- Sometimes rogue plants are not distinguishable before flowering, therefore, rouging should be done, as early as blooming starts.
- Doubtful plants too should be rouged.
- The rogued plants should be removed from the field immediately after rouging and destroyed as they may survive for a few days and may spread their pollen.

Rouging for Quality Seed Production

Rouging is the removal of plants that are off type that is phenotypically different from the plants of the variety under production. It is an important aspect of seed production and is necessary to prevent out-crossing and mechanical mixtures.

The off-type plants are to be regularly removed from the field either by uprooting or by cutting at the ground level.

The off-type plants may differ in

- Plant height: Taller or shorter than most of the plant.
- Plant characters: Presence or absence of awn etc.
- Leaf characters: Different leaf colour, different angle of flag leaf, erect or droopy leaf type etc.
- Flowering time: Early or late flowering or panicle initiation.
- Maturity: Different time
- Panicle: Rogue plants with partially exerted panicles because at heading time, these off-types will have earlier or later panicle emergence.
- Flag leaf angle: Rogue plants with flag leaf that is upright (A) or bent (B) unlike the rest of the plants.
- Leaf colour, sheath, stem: Rogue plants that have discoloured or differently-coloured leaves, sheath, and stems.

Besides off-type plants, diseased plants, weeds above or below the canopy, lodged or disabled plants, mechanically damaged plants, etc. should also be removed or rouged out to obtain a clean seed production field. The upper view of a rouged plot should look fairly plain and distinct.

Major Sources of Off-type Plant

There are three main sources of off-type

1. The off-type plant may be arising due to the presence of recessive genes in heterozygous condition at the time of release of variety. (The recessive genes may also arise by mutation).
2. Off-type plants are due to volunteer plants or from seeds produced by earlier crops.
3. Mechanical mixtures also constitute the major source for off-type plants.
4. Rouging in Certified Seed Production

The most important object of seed production is to maintain the genetic purity of the variety or hybrids seed plot. For this purpose, it is necessary to follow rouging vigorously.

Rouging consists of the removal of

a) Off types
b) Volunteer plants
c) Pollen shedders in female (A) lines,
d) Plants of noxious weeds and other crops,
e) Diseased plants affected by seed-borne diseases growing in the seed plot and
f) Tassels from plants in the female rows of seed production of single hybrids and double hybrids in maize.

Procedure:

Rouging is to carried in three phases

A) Pre-Flowering
B) During Flowering and

C) Post flowering or before harvesting.

During the pre-flowering period plants that are morphologically distinguishable from true characters of the variety should be removed. Similarly, volunteer plants, other crop plants, and weed plants should also be checked.

During the flowering period which lasts for 15 to 30 days rouging should be carried more critically and all off types, volunteer plants, and pollen shedders in MS lines should be removed before shed pollens. Timely rouging during flowering helps in preventing natural cross-pollination and also reduces the proportion of off-types. Simultaneously isolation area on sides of seed plot be checked for removing volunteer plants before they flower. Plants affected by seed borne diseases, other crop plants, and tall-growing weed plats should also be removed. In the case of seed plots of both single and double hybrids of maize work of detasseling should be carried out in female lines before they shed pollens.

Rouging should be continued during seed development stage and before harvesting for removing visibly distinct off types other crop plants and diseased plants. Post flowering rouging is admissible in seed production of self-pollinated crops.

Activity 2: Seed sampling for seed testing and preparation of submitted sample and working sample for seed test

Objectives: Sampling is done to get a uniform and representative sample from a seed lot.

The size of the submitted sample required for testing is small as compared to the size of the lot, therefore, care must be taken to ensure that the submitted sample represents the lot of the seed to be tested.

Hence the samples must be prepared in accordance with ISTA rules to ensure that the small size sample should represent truly and in the same proportion all constituents of the seed lot.

Definition of samples

The seed lots received by a laboratory for analysis and testing are given an accession number of each variety for future reference.

A seed lot to be sampled must not be heterogeneous i.e. the primary samples drawn from the lot should be similar in constitution. If there is any evidence of heterogeneity test of the primary samples drawn, as defined by ISTA rules, further sampling and testing from the seed lot should not be continued.

Seed lot: A seed lot is a specified quantity of the seed of one cultivar of known origin as physically identifiable.

Methods of sampling

1**. Hand sampling**

This is followed for sampling the non-free flowing seeds or chaffy and fuzzy seeds such as cotton, tomato, grass seeds, etc. In this method, it is very difficult to take samples from the deeper layers of the bag. To overcome this, bags are emptied completely or partly and then seed samples are taken. While removing the samples from the containers, care should be taken to close the fingers tightly so that no seeds escape.

2. **Sampling with triers/Probe**

By using appropriate triers, samples can be taken from bags or bulk. The triers are used for taking free flowing seed samples.

a**) Bin samplers**

Used for drawing samples from the lots stored in the bins.

b) **Nobbe Trier**

The name was given after the father of seed testing Fredrick Nobbe. This trier is made in different dimensions to suit various kinds of seeds. It has a pointed tube long enough to reach the centre of the bag with an oval slot near the pointed end. The length is very small. This is suitable for sampling seeds in bags not in bulk.

c) **Sleeve type triers or stick triers**

It is the most commonly used trier for sampling: There are two types viz., 1. With compartments 2. Without compartments. It consists of a hollow brass tube inside with a closely fitting outer sleeve or jacket which has a solid pointed end. Both the inner tube as well as the outer tube have been provided with openings or slots on their walls. When the inner tube is turned, the slots in the tube and the sleeve are in line. The inner tube may or may not have partitions.

This trier may be used horizontally or vertically. This is diagonally inserted at an angle of 30°C in the closed position till it reaches the centre of the bag. Then the slots are opened by giving a half turn in a clockwise direction and gently agitated with inward push and jerk so that the seeds will fill each compartment through the openings from different layers of the bag, then it is again closed and withdrawn and emptied in a plastic bucket.

Sleeve type triers

This trier is used for drawing seed samples from the seed lots packed in bags or contain-ers. A thief trier should not be used because it is not long enough to take a representative portion of the sample from the individual container.

Method of preparing composite samples

- When the primary samples appear uniform, they are combined and thoroughly mixed to form the composite sample.
- From the composite sample, the submitted sample of requisite weight or more is obtained either by repeated halving or by abstracting and subsequently combining small random portions.

Types of sampling

1**. Primary sample**

Each probe or handful of samples taken either in a bag or in bulk is called primary sample.

2. **Composite sample**

All the primary samples drawn are combined in a suitable container to form a composite sample.

3. **Submitted sample**

When the composite sample is properly reduced to the required size that is to be submitted to the seed testing laboratory, it is called a submitted sample. A submitted sample of requisite weight or more is obtained by repeated halving or by abstracting and subsequently combining small random portions.

4. **Working sample**

It is the reduced sample with the required weight obtained from the submitted sample after repeated mixing and dividing with which the seed quality tests are conducted in the seed testing laboratory.

Sampling intensity

Seed Size	Maximum quantity per lot
Larger than wheat and paddy	20,000 kg

Smaller than wheat and paddy	10,000 kg
Maize	40,000 kg

Sampling intensity

The intensity of sampling should be maintained in accordance to the rules described by ISTA. When seeds are stored in bags or other containers of similar capacity that are uniform in size.

a. For seed lots in bags (or containers of similar capacity that are uniform in size)

up to 5 containers	Sample each container but never < 5 Primary Sample (PS)
6-30 containers	Sample at least one in every 3 containers but never> than 5 Primary Sample
31-400 containers	Sample at least one in every 5 containers but never < 10 Primary Sample Sample
401 or more	Sample at least one in every 7 containers but never < 80 Primary Sample

When the seed is in small containers such as tins, cartons, or packets a 100 kg weight is taken as the basic unit, and small containers are combined to form sampling units not exceeding this weight e.g. 20 containers of 5 kg each. For sampling purpose, each unit is regarded as one container.

b. **For seeds in bulk**

Up to - 500 kg	At least 5 Primary samples
501 - 3000 Kg	One primary sample for each 300 kg but not less than 5 primary samples
3001-20,000 Kg	One primary sample for each 500 kg but not less than 10 primary samples
20,001 and above	One primary sample for each 700 kg but not less than 40 primary samples

Instructions for sending samples

- A pre-requisite in sampling is that the seed lot received in containers/bags must be properly sealed and marked for identification with a single lot designation.
- At the time of sampling, all the samples drawn must bear identification corresponding to that of the lot certificate.
- The sampler should seal or supervise the sealing of the sample container / bags after drawing sample.
- After taking samples that may be more than required for seed testing purpose, a thorough mixing of the samples is to be done.
- Divide it using a seed divider and then the required amount should be submitted to the seed testing laboratory after putting a proper identification mark.
- If a mechanical divider is not available at the spot, a representative sample should be obtained by putting the entire quantity of seed on a clean floor, mixing properly, and halving the sample until the desired quantity is obtained.
- For moisture determination, 100g of seeds for species that need grinding and 50g for all other species. The sample should be submitted in an air-tight container, like polythene bags of 700 gauge or a glass bottle with tight caps to the laboratory.

Quantity and dispatch of sample for testing

Weight of submitted sample

The minimum weight for submitted samples for various tests are as follows.

1. Moisture test- 100 g for those species that have to be ground and 50 g for all other species.
2. For verification of species and cultivar

Crop	**Lab only (g)**	**Field plot & Lab (g)**
Peas, beans, maize, soybean and crop seeds of similar size	1000	2000
Barley, oats, wheat and crop seeds of similar size	500	1000
Beet root and seeds of similar size	200	500
All other genera	100	250

Dispatch of the submitted sample

- Each submitted sample should be sealed and marked
- The label should contain all the necessary details such as variety, class of seed, quantity in the lot, to whom it belongs, name of the producer, seed treatment, date of harvesting and threshing if known, sampled by, date of sampling, and the kind of tests required.
- After marking the sample, it should be packed so as to prevent damage during transit. For the germination test sample should be packed preferably in cloth bag, for moisture content determination, sample should be packed separately in moisture proof containers.
- Samples should be dispatched by the sampler to the seed testing laboratory without delay.

Types of samples used in Seed Testing Laboratory (STL)

Service sample: Sample received from other than seed certification agencies and seed inspectors
Certified sample: Sample received from certification agencies or officers
Official sample: Sample received from the seed inspectors.

For other tests like purity and count of other speciesMake pr0per allingment of the figures in the Table**Crop**	**Size of seed lot (Kg)**	**Size of submitted sample (g)**	**Size of working Sample for purity analysis (g**	**Sample count of other species(g)**
Paddy	20,000	400	40	400
Wheat	20,000	1000	120	1000
Maize	40,000	1000	900	1000
Sorghum	10,000	900	90	900
Bajra	10,000	150	15	150
Redgram	20,000	1000	300	1000
Greengram	20,000	1000	120	1000
Blackgram	20,000	1000	150	1000
Bengalgram	20,000	1000	1000	1000
Cowpea	20,000	1000	400	1000
Soybean	20,000	1000	500	1000
Groundnut(pods)	20,000	1000	1000	1000
Groundnut(Kernels)	20,000	1000	600	1000
Gingelly	10,000	70	7	70
Sunflower(variety)	20,000	1000	250	1000

Sunflower(Hybrid)	20,000	1000	125	250
Cotton linted(variety)	20,000	1000	350	1000
Cotton delinted(variety)	20,000	350	35	350
Cotton linted(hybrid)	20,000	350	35	350
Cotton delinted (hybrid)	20,000	25	25	250
Brinjal	10,000	150	15	150
Chillies	10,000	150	15	150
Bhendi	10,000	150	15	150
Tomato(variety)	10,000	70	7	70
Tomato(hybrid)	10,000	7	7	7
Cabbage	10,000	100	10	100
Cauliflower	10,000	100	10	100
Knolkhol	10,000	100	10	100

Source: M. Bhaskaran et al. (2003). Textbook of "Principles of seed production and quality control".

Activity 3: Seed testing (physical purity, viability, seed germination)

A. Physical purity analysis

Objectives:

1. To determine whether the submitted seed sample (by inference the seed lot) conforms to the prescribed quality standards regarding purity components.
2. To assess the planting value of the seed lot.
3. To get the pure seed fraction for further analysis/ tests.

Components of physical purity: 1. Pure seed, 2. Other crop seed. 3. Weed seed and 4. Inert matter.

Pure seed: The pure seed fraction refers to the seed of kinds/ species stated by the sender or found predominantly in the seed sample.

i) The structures, even if immature, undersized, shriveled, diseased, or sprouted, provided they can be identified as of that species are regarded as pure seed, unless transformed into fungal sclerotia, smut ball or nematodes gall etc.
ii) The whole seed unit or pieces of seed unit larger than half of original size.
iii) Intact seed units or pods in the case of groundnut.

1. Other crop seed: it refers to the kinds of crops other than the kind being examined.
2. Weed seed: It includes seeds of those spps. normally recognized as weeds or specified under a regulation of seed act as a noxious weed.

   N.B. 1. For classification as OCS and WS, the distinguishable characteristics described under pure seed shall be applicable.

4. **Inert matter**: It includes seed units and all other matter and structures that are not defined as pure seed, or other crop seed.

Materials: Purity work board, Boerner divider, Graduated sieve, seed blower, balance, forceps, etc.

Pic 1. Purity work board

Pic 2. Boerner Divider

Pic 3. Electronic balance

General procedure for purity Analysis:

1. It is done on the working sample drawn from the submitted sample.
2. Draw a working sample of the prescribed weight given for the crop under examination
3. Use sieves or seed blowers, whenever necessary.
4. Place the working sample or subsample on the clean surface of a purity work board slightly to the rear and left of the centre.
5. With the help of forceps and spatula having straight smooth edges draw a few seeds at a time from the pile spreading than apart by pulling them towards the front of the board.
6. Examine each seed, seed unit and particle carefully and separate them into pure seed, other crop seed, weed seed, and inert matter.
7. Re-examine each component to ensure that the separation of each has been done accurately.
8. Each of the components must be weighed separately to the requisite number of decimal places.
9. The percentage of the components is determined on the basis of sum of weights of the components, not on the weight of the original sample.

i) Pure seed (%) = $\dfrac{\text{Wt of pure seeds x 100}}{\text{Total weight of all components}}$

ii) Other crop seed (%) = $\dfrac{\text{Wt of other crop seeds x 100}}{\text{Total weight of all components}}$

iii) Weed seed (%) = $\dfrac{\text{Wt of weed seeds x 100}}{\text{Total weight of all components}}$

iv) Inert seed (%) = $\dfrac{\text{Wt of inert matter x 100}}{\text{Total weight of all components}}$

Reporting results:

The purity analysis report should be given up to one decimal place and the percentage of all components must total 100. Components of less than 0.05% should be reported as 'Trace". If the results of a component are nil, this must be shown as '0.0' in the appropriate column. For the report card refer

Annexure-1

Annexure -1 Purity Analysis Report.

1. Test No.
2. Kind
3. Variety
4. Lot no.
5. Sample No.
6. Purity fractions in % percentage
7. Pure seed
8. Other crop seed
9. Weed seeds
10. Inert matter
11. Other spps No./kg

B. Seed viability test using tetrazolium (tz)

Objective:

i) To determine the viability of seed lots within a short time to make fast decisions in marketing the seeds even if seeds are dormant.

Importance: This is particularly useful for freshly harvested seeds that possess high levels of dormancy such as some grasses and native species. The results of the TZ test indicate the number of viable seeds in a sample that are capable of producing normal plants under suitable germination conditions.

While germination test takes 3-4 weeks to be completed in most grass species, a TZ test can be finished within 24-48 hours. High correlations between TZ and germination test results were observed in non-dormant seeds.

The principle of the tetrazolium test

The TZ is a biochemical test, which differentiates live from dead seeds based on the activity of the respiration enzymes in seeds. Upon seed hydration, the activity of dehydrogenase enzymes increases resulting in the release of hydrogen ions, which reduces the colorless tetrazolium salt solution (2,3,5-*triphenyl tetrazolium chloride*) into a chemical compound called formazan. Formazan stains living cells (respiring) with a red color while dead cells (not respiring) remain colorless. The viability of seeds is interpreted according to the staining pattern of seed tissues.

Procedures

The main steps in conducting a TZ test are:

1. Hydration: seeds must be completely imbibed in order to activate respiration enzymes. This process is needed to release hydrogen ions.

2. Cutting or puncturing: This process permits the access of the TZ solution to the internal tissues of seeds. For some grasses, e.g., bentgrass and Kentucky bluegrass, piercing seeds is performed under the microscope for accuracy. For fescues and ryegrass cutting is performed under a magnifying lens. Knowledge of morphology of various seed species is essential for appropriate cutting and piercing of seeds. Preparing grass seeds for TZ test is somewhat time-consuming compared to soybean or corn because of the size of the seeds.

3. Staining: Seeds are placed in a TZ solution (0.1-1.0%) for a period of time as indicated in the AOSA TZ Handbook. During this process hydrogen ions reduce the colorless TZ solution to red formazan, which stains live tissues with red color while dead tissues remain unstained (Figures 1,2, and 3).

4. Evaluation: Critical evaluation of the TZ staining pattern and intensity is needed for accurate interpretation. For reliable evaluation, seed analyst should be familiar with the structure and the anatomy of the seeds to identify the location of the embryos and determine their staining pattern. In some grasses, lactic acid is used to allow for a clear vision of the internal tissues through the seed coat.

The Tetrazolium Testing Handbook of the Association of Official Seed Analysts (AOSA) has detailed techniques for conducting TZ test for a wide range of species.

Like any other seed testing method, the TZ test requires special training and experience. A high level of training is not unique to the TZ test; it is a basic requirement in any test such as purity, germination, ploidy, etc.

Pic: Sample picture of Tetrazolium test result

Tetrazolium concentration	Seed Categories	Immersion time of the seeds intetrazolium solution		
		2 Hours	4 Hours	6 Hours
0.50%	Viable			
	Not Viable			
0.75%	Viable			
	Not Viable			
1.0%	Viable			
	Not Viable			

SOIL SCIENCE

Skill Set (SSAC) 1: Determination of pH of soil

Principle:

The pH represents the acidic, neutral or alkaline reaction of the soil. The degree of acidity or alkalinity can be represented by its intensity. The pH is defined as the negative logarithm to the base 10 of H^+ ions activity (concentration) expressed in g ions (moles) l^{-1} of solution and expressed by the equation: $pH = -\log_{10} [H^+]$ or $pH = \log_{10} 1/[H^+]$. This concentration is practically measured by the difference of electric potential produced between a glass and a reference electrode.

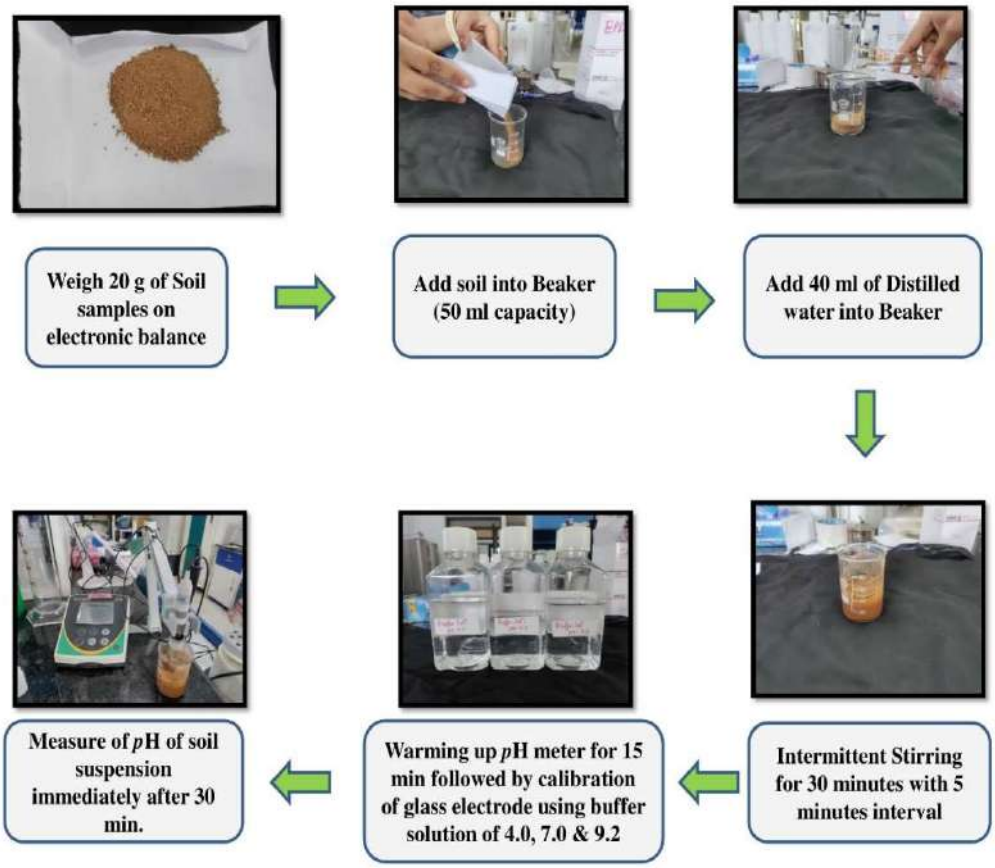
Skills to be developed

1. Students will understand the principle and operating knowledge of the pH meter.
2. To know whether the soil is acidic, neutral or alkaline in nature

Apparatus and Reagents:

1. pH meter with glass and reference electrode
2. Beaker
3. Buffer solutions (4.0,7.0 and 9.2 pH): Buffers are the solutions that have exact pH and resist changing pH.

Procedure: (1:2 Soil water solution)



Soil pH Rating:

pH	**Soil Reaction**
<5.0	Strongly acidic
5.0-6.5	Moderately to slightly acidic
6.5-7.5	Neutral
7.5-8.5	Moderately alkaline
>8.5	Strongly alkaline

Learning Outcomes:

- Gain the knowledge of procedure of pH determination in soil
- Experience in the working of soil testing lab

Skill Set (SSAC) 2: Determination of electrical conductivity (EC) of soil

Principle:

The electrical conductivity (EC) represents the total soluble salts (Ca, Mg, K etc) present in a soil solution. It obeys Ohm's law and EC measures ionic transport in soil and water solution between anode and cathode. Since the EC depends on the number of ions in the solution, it is important to know the soil/water ratio used. The most common method of EC determination in Neutral to Acidic soils is 1:2 soil water suspension methods, which is a very quick method.

Apparatus/ Glassware

- Electrical conductivity meter
- Beakers

Reagent

- 0.01M Potassium chloride standard solution: Weight 0.7456 g KCl and dissolve in a distilled water and make the volumetric flask volume to one litre. This solution gives an electrical conductivity of 1411.8 x 10^{-3} or 1.412 dSm^{-1} at 25°C. Standardize EC meter with the help of 0.01 M KCl before taking a reading on an instrument.

Procedure:

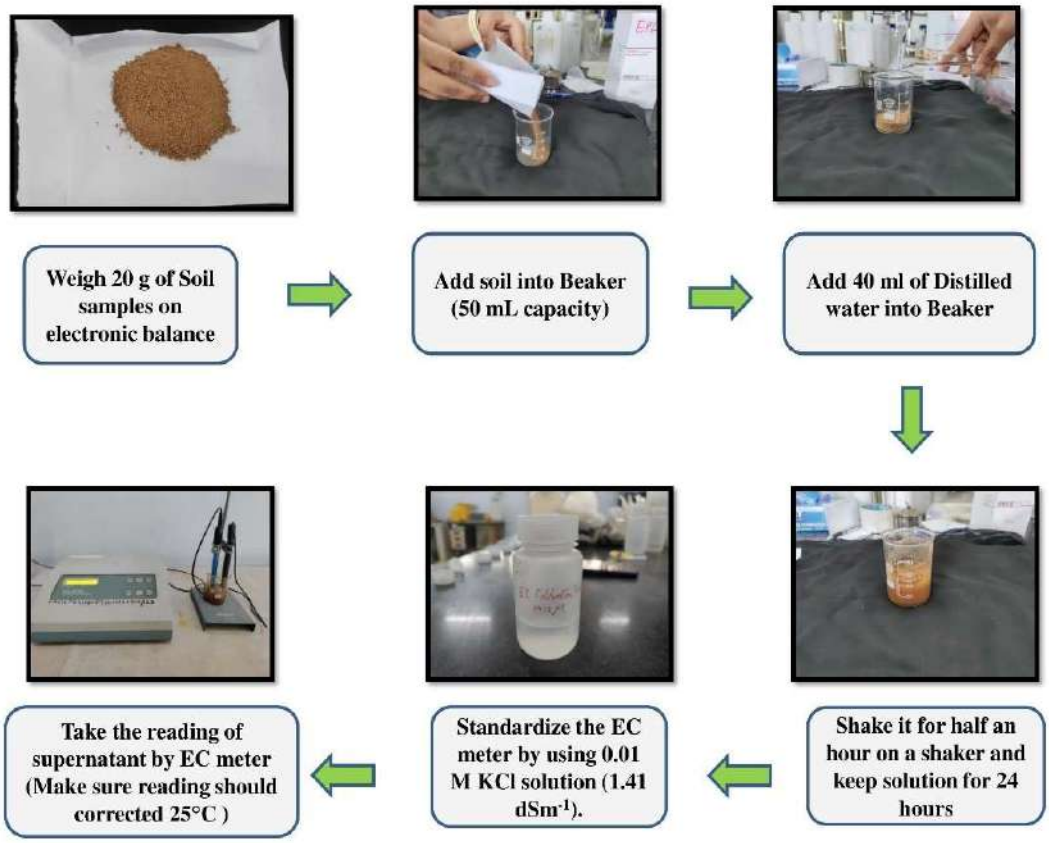


Table : General interpretation of EC values

S. No.	Soil	EC (dSm^{-1})	Crop reaction
1.	Salt free	0-2	Negligible effect of salinity
2.	Slightly saline	4-8	Crop can grow with proper management practice
3.	Moderately saline	8-15	Grow salt tolerant crops with proper management practice
4.	Highly saline	>15	Grow salt tolerant crops with proper management practice, leaching of salt by good quality irrigation water

Learning Outcomes

- Gain the knowledge of procedure of Electrical Conductivity determination in soil
- Experience in the working of soil testing lab

Skill Set (SSAC) 3: Determination of soil texture by Bouyoucos Hydrometer

Introduction:

Soil texture is a relative proportion of the sand, silt, and clay in the soil. It is a permanent property of the soil. Soil texture determined several other physical and chemical properties of the soils. Thus, the management of soils requires an understanding of soil texture.

Principle:

The hydrometer method is most commonly used for the determination of soil texture. It is based on Stoke's law. It is predicated on the soil particles' dispersal and sedimentation. The soil particles were dispersed by using sodium phosphate hexametaphosphate (HMP), which replaces the divalent and trivalent cations with monovalent cations, and the soil gets dispersed. The rate of sedimentation of soil particles in water differs with the radius of the soil particles. The hydrometer measures the density of the soil water suspension which changes as per the sedimentation of particles.

Apparatus:

1. Hydrometer with Bouyoucos scale in g/L, 2. Mechanical stirrer, 3. Water bath,

4. Thermometer, and 5. Stopwatch

Reagents:

1. 5 % Sodium hexametaphosphate (HMP)
2. 6% Hydrogen peroxide
3. Amyl Alcohol

Glassware:

1. 1 Litre Measuring cylinder with stopper
2. Beaker 500 ml

Procedure:

- Pass the soil through 2 mm sieve
- Take 100 g of soil based on oven dried condition into a beaker
- Add 50 ml of 6 % H_2O_2 and place it on a water bath until the organic matter dissolved
- Repeat the process until the frothing stops
- Add 400 ml water and 100 ml of HMP solution into it. leave for overnight
- Stir the suspension with the help of mechanical stirrer for 10 minutes
- Transfer the suspension into a 1 litre measuring cylinder and make the suspension up to 1 litre mark
- In another cylinder, add 100 ml of HMP solution and make the volume to 1 L with distilled water. Mix thoroughly with a plunger and record the temperature.
- Place a stopper over the mouth of the cylinder and shake vigorously for 1 minute
- Place the cylinder on a table and note the time immediately
- Insert the hydrometer into suspension and take the reading after 4 minutes, the particle > 0.02 mm has settled down. if the suspension is frothy, add 1 drop of amyl alcohol.

- Remove the hydrometer and carefully wash it with distilled water. Record the temperature of suspension
- Allow the suspension to remain undisturbed and reinsert the hydrometer at the end of 2 hours
- Record the temperature at 4 minutes and 2 hours.
- Calculate the sand, silt, and clay composition in percent and determine the texture using the ISSS textural triangle

Calculation:

For every 1°C above 20°C, a 0.2 graduation is added to the hydrometer reading and for every 1°C below 20°C, a 0.2 graduation is subtracted.

Use the corrected reading (as per the temperature) for the calculation.

$$\%\ (Silt + Clay) = \frac{Reading\ of\ soil\ suspension\ (4\ min) - Reading\ of\ Blank(4\ min)}{Weight\ of\ oven\ dry\ soil\ (g)}$$

$$\%\ Clay = \frac{Reading\ of\ soil\ suspension\ (2\ H) - Reading\ of\ Blank(2\ H)}{Weight\ of\ oven\ dry\ soil\ (g)}$$

$$\%\ Silt = \%\ (Silt + Clay) - Clay$$

$$\%\ Clay = \%100 - \ (Silt - Clay) - Clay$$

Soil Texture Triangle:

Get the class of soil texture by placing value of % sand, silt and clay.

Skill Set (SSAC) 4: Identification of soil colour (Munsell soil colour chart)

Principle:

- The colour of the soil samples is measured by matching with a chart known as the "Munsell soil colour chart".
- The book contains seven sets of colour charts. There are three major colour variables: Hue, value, and chroma.
- The hue notation of colour indicates its lightness, the value indicates the intensity of the colour and the chroma indicates its strength.

Materials:

1. Munsell Colour Book
2. Soil
3. Distilled water

Procedure:

Soil samples are collected from the field at different depths.

Hold the soil sample properly so that the diffuse light incident properly to the soil sample.

Select a page from the Munsell soil colour chart that contains colour close to the sample.

Find the colour chips that gives the best match with the colour of the soil.

Note the Munsell colour notation and the soil colour name.

In writing the Munsell notation, the order is Hue, Value and Chroma with the space between the Hue letter and the succeeding value number.

A dry soil of Hue 5YR, value 5, chroma 6 and yellowish red should be described as yellowish red (5YR 5/6 dry).

Moist soil colour will be described in a similar manner.

Skill Set (SSAC) 5: Determination of available potassium (K) content in soil

Principle:

Potassium determination using a flame photometer is based on the following assumption:

- Alkali metals (Group-I) and alkaline earth metals (Group-II) such as K, Na, Ca, and Ba are sensitive to flame photometers due to their low excitation energies.
- Flame photometry measures the intensity of light emitted when a metal is introduced into the flame.
- The wavelength of colour tells us about the name of the element (qualitative); whereas the intensity of colour tells us the quantity of element present in the sample.

- The flame colour for potassium (K) is violet under emitted light at a wavelength of 766 nm.

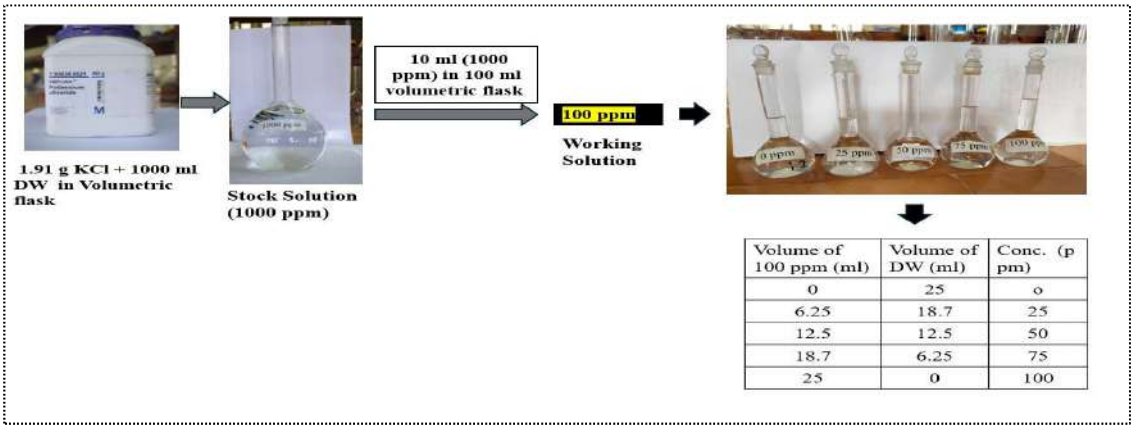
Apparatus Required:

Flame Photometer		**Funnel**	
Balance		**Volumetric flask**	
Shaker		**Conical Flask**	
Pipettes		**Whatman Filter Ppaer-1**	

Reagents preparation:

1. Neutral N ammonium Acetate (NH_4OAc): Dissolve 77.09 g of NH_4OAc in distilled water and make up a volume of 1 L. Adjust the solution pH to 7.0 by adding acetic acid or NH_4OH Solution as required.
2. Standard K Solution (1000 ppm): Dissolve 1.91 g of KCl (AR) in distilled water and make up the volume to 1 L.
3. Working K Standard Solution (100 ppm): Pipette out 10 ml standard solution into a volumetric flask and make up the volume to 100 ml using distilled water. Further, 0, 25, 50, 75, and 100 ppm K solution was prepared using 100 ppm.

Standard Preparation for K:

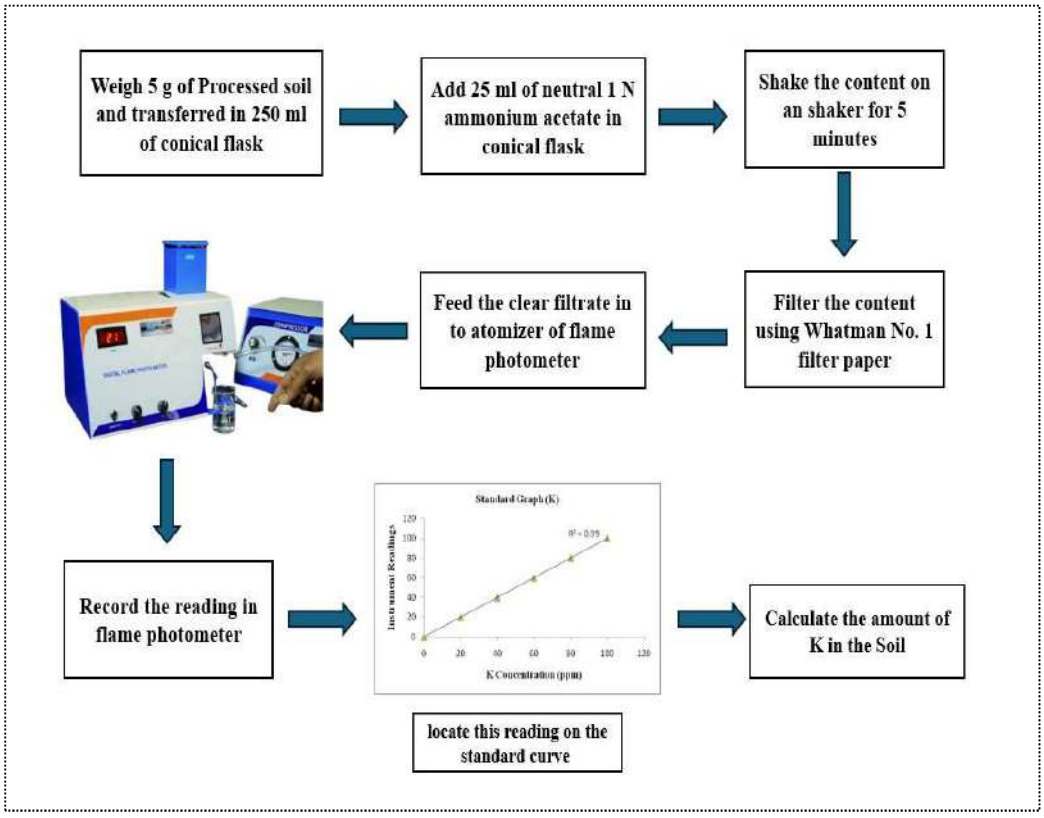


Volume of 100 ppm (ml)	Volume of DW (ml)	Conc. (ppm)
0	25	o
6.25	18.7	25
12.5	12.5	50
18.7	6.25	75
25	0	100

Standard Curve Preparation:

1. Adjust the flame photometer reading to read 0 with the blank solution and 100 with 40 ppm K solution then take readings for other concentrations.
2. Plot the curve by taking flame photometer readings on the y-axis and K concentration in ppm on the X-axis.

Procedure flow chart:



Calculation:

(a) Weight of soil taken- 5 g

(b) Volume of 1 N NH_4OAc- 25 ml

Available K_2O (kg ha^{-1}) = $\frac{Graph\ ppm\ \times Vol.of\ extractant\ \times 2.24}{\text{Wt. of Soil}}$

Interpretation of results:

Available K_2O (kg ha^{-1})	Rating
<130	Low
280	Medium
>280	High

Precautions/ Comments/Suggestion

1. The filtrate should be clear to avoid choking of capillary tube of the flame photometer.
2. During the operation of the flame photometer, a constant air pressure (0.75 kg cm^2) and steady flow of gas is necessary for precise estimation.
3. Potassium Standard should be prepared fresh after every 2-3 weeks.
4. The ammonia bottle should be cooled before opening.

Skill Set (SSAC) 6: Determination of DTPA-extractable soil micronutrients (Zn, Cu, Fe and Mn)

Principle:

- Diethylene triamine Penta acetic acid (DTPA), a chelating agent, combines with free metal ions in solution and forms soluble complexes. Due to the reduced ionic activity in solution desorption takes place, bringing in some more ions from solid phase.
- DTPA offers the most favourable combination of stability constants for the simultaneous complexing of Zn, Cu, Fe and Mn.
- DTPA Extractant has the ability to chelate Zn, Cu, Fe and Mn in competition with $Ca^{2+}$and $Mg^{2+,}$ and unlike most other chelating agents, it applies a Moderate stress to solubilize soil Fe at a pH where $CaCO_3$ is not dissolved.

Apparatus Required:

i. Atomic absorption spectrophotometer (AAS) ; ii. Mechanical shaker

Determination of DTPA-extractable Zn:

Reagents:

1. Dilute HCI: Dilute AR grade HCI 5 times with double distilled water (DDW).
2. DTPA extractants: Dissolve 1.967 g of AR grade diethylene-triamine Penta acetic acid (DTPA) + 1.470 g of $CaCl_2.2H_2O$ (AR grade) in about 25 mL of double distilled water (DDW) by adding 13.3 mL of triethanol amine (TEA), followed by 100mL more of DDW. Transfer the solution to a one litre volumetric flask giving 4 to 5 washings. Just before making up the volume, adjust pH to 7.3 with dilute HCI.
3. Standard stock solution 'A'(1000 mg Zn L^{-1}): Dissolve 1.0g of pure Zn metal (AR grade) and in about 10 mL of dil. HCI (1:1) and make the volume to one litre.

Or

Readymade Zn stock solution (1000 mg Zn L^{-1})

4. Standard solution 'B' (50 mg Zn L^{-1}): Dilute 5 mL of solution A to 100 ml
5. Standard working solutions: Prepare working standards containing 0, 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0 mg ZnL^{-1}

Glasswares/ particulars required: Conical flask, Funnel, Pipette, Volumetric flask, Wash bottle, Filter paper

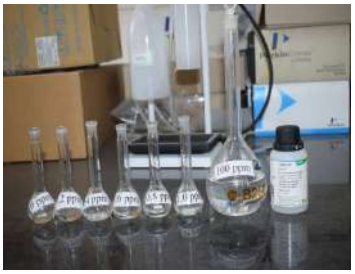
Procedures:

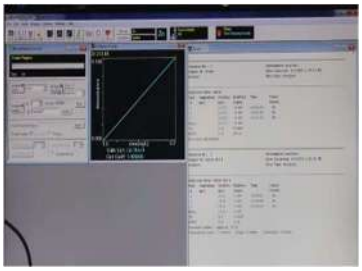
Weigh 10g of soil sample in 100 ml conical flask

Add 20 ml of DTPA extractant and shake for 2 hrs in mechanical shaker

Filter through Whatman no. 42 filter paper and use the filtrate for Zn measurement on AAS.

Fit the standard working solutions and prepare a standard curve by plotting AAS readings against zinc concentration





Take reading for the aliquot samples

Calculation:

- DTPA extractable zinc in soil (mg kg $^{-1}$) = (A×20)/10

  Where,

  A=Zn concentration in aliquot as read from X-axis of standard curve against the sample reading.

Rating:

Low: < 0.5 mg kg^{-1}
Marginal: 0.50-0.75 mg kg^{-1}
Adequate: 0.75-1.50 mg kg^{-1}
High: >1.50 mg kg^{-1}

The working standards should be prepared in the medium of the extracting solution after every few days as these cannot be preserved for long.

B. Determination of DTPA-extractable Cu:

Available copper can be determined in the DTPA extract similar to Zn using AAS. For this, the standard stock solution can be prepared as given below:

1. Standard stock solution 'A'(1000mg Cu L^{-1}): Accurately weigh 1.0g AR grade copper metal wire or turn and dissolve in 50 mL of diluted HNO_3 (1:1 with DDW) and finally make the volume to one litre.

   Or

   Readymade Cu stock solution (1000 mg Cu L^{-1}) can be used.
2. Prepare solution B containing 50 mg Cu L^{-1} by diluting appropriate volume of solution A.
3. Finally prepare working standards containing 0, 2, 4, 6, 8 and 10 mg Cu L^{-1} from solution B.

C. Determination of DTPA-extractable Fe:

Iron in the DTPA extract can also be determined with the help of AAS exactly in the same manner as Zn and Cu described above.

1. Standard stock solution 'A'(1000 mg Fe L^{-1}): Dissolve 1.0 g of AR grade Fe metal in about 50 mL of 1:1 diluted HNO_3 and dilute the contents to one litre with DDW.

   Or

   Readymade Fe stock solution (1000mg Fe L^{-1}) can be used.
2. Prepare solution 'B' by diluting 50 mL of solution 'A' to 500 mL to get 100 mg Fe L^{-1}.
3. Finally prepare working standard solutions containing 0, 2, 4, 6, 8, and 10 mg Fe L^{-1} by diluting the appropriate volume of solution B with the medium of extraction (DTPA).

D. Determination of DTPA-extractable Mn:

DTPA-extractable Mn is also determined following the same technique as adopted for Zn, Cu and Fe. For this, prepare the standard solutions as follows:

1. Standard stock solution 'A'(1000 mg Mn L^{-1}): Weigh 1.583 g of AR grade MnO_2 or 1.0 g of pure Mn metal and dissolve it in 50 mL of diluted HNO_3 (AR grade). Make the volume to 1 Litre with DDW to get solution A having a Mn concentration of 1000 mg L^{-1}.

   Or

   Readymade Mn stock solution (1000 mg Mn L^{-1}) can be used
2. From solution 'A dilute 25 mL to 250 mL with DDW to get solution B having 100 mg Mn L^{-1}.
3. Finally prepare working solutions of 0, 2, 4, 6, 8 and 10 mg Mn L^{-1} concentrations.

Rating:

	Deficient	**Sufficient**
DTPA-extractable Cu	< 0.2 mg kg^{-1}	> 0.2 mg kg^{-1}
DTPA-extractable Fe	< 4.5 mg kg^{-1}	> 4.5 mg kg^{-1}
DTPA-extractable Mn	< 1 mg kg^{-1}	> 1 mg kg^{-1}

Skill Set (SSAC) 7: Determination of water holding capacity of soil by percolation method

Principle:

The soil water holding capacity refers to the quantity of water that retained in the soil's capillary spaces following the downward movement of gravitational water into deeper layers. The water holding capacity of soil is determined by the presence of capillary pore spaces. Sandy soil exhibits a minimal water holding capacity, while clayey soils possess a significantly higher water holding capacity.

Materials required:

i) Graduated measuring cylinder (100 or 250 ml), ii) Beakers (100 or 250 ml), iii) Funnels, iv) Filter paper, and v) Weighing scale

Procedure:

i) Weigh 25 grams of each soil samples
ii) Pour in the container and label the container
iii) Take the filter paper circle and fold it twice. Open one of the folds to make a cone.
iv) Insert the filter paper cone into the funnel
v) Place this funnel in the mouth of a graduated cylinder.
vi) Prepare such identical appropriately labelled setups.
vii) Take the pre weight soil samples & carefully pour them one by one into the filter paper cones of the funnels
viii) Introduce 50 ml of water into labelled beakers
ix) Carefully add the water from each beaker into the soil containing funnels in small increments. Do not add water beyond the level of the filter paper cones. As we keep on adding water it will eventually seep through the soil samples trickle down through the funnels and get collected in the graduated cylinders. Once all the water contents of the beakers have been poured into the funnel, leave the percolation setups undisturbed for several minutes until no more water trickles through the stem of the funnel
x) Once all the water contents of the beakers have been poured into the funnel, leave the percolation setups undisturbed for several minutes until no more water trickles through the stem of the funnel
xi) Measure the volume of water collected in each of the measuring cylinders

Tabulate the observations as given below:

Sample	Weight of sample (g)	Volume of water poured through V1 (ml)	Volume of water collected in measuring cylinder V2 (ml)	Volume of water retained by soil (V1-V2) ml	% water holding capacity (WHC)
1	25 g	50 ml	30 ml	20 ml	80%
2	25 g	50 ml	37 ml	13 ml	52%
3	25 g	50 ml	29 ml	21 ml	84%

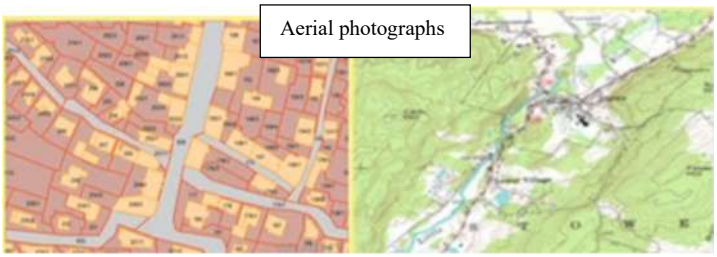
$$\text{Water holding percentage (\%)} = \frac{Volume\ of\ water\ retained\ by\ soil(V1-V2)}{Weight\ of\ sample\ (w)} \times 100$$

Skill Set (SSAC) 8: Soil Survey

Soil survey is defined as a study and mapping of soils in their natural environment. It is the systematic examination, description, classification and mapping of soils of an area. It involves the following group of interlinked operations:

1. Background study: All the data available about the site to be surveyed such as former information, aerial photograph and maps or any available inputs are collected together.

Aerial photographs



Cadastral map

Topographical map

2. Ground verification of collected geo-referenced information such as aerial photographs or remote sensing data: Integrated transact walks can be done by a multidisciplinary team in presence of locals to verify the extent of accuracy of the collected data or information.

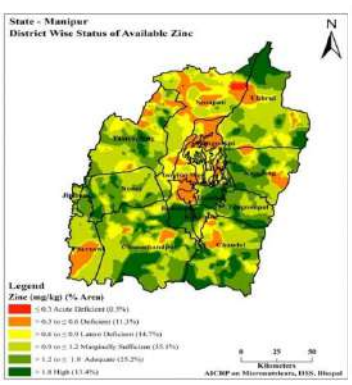
3. Soil sampling and in-depth soil profile analysis: After transect walks, sites are located for in-depth soil analysis or profile analysis that can be done by recording coordinates, geological formation, parent materials, physiographic, altitude, land use and vegetation

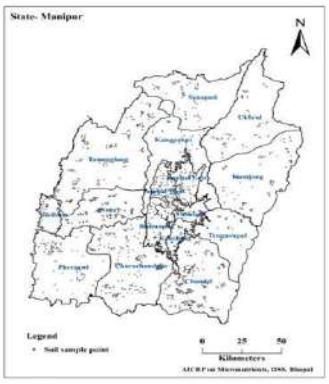
4. Extrapolation and boundary verification


5. Analysis in laboratory to supplement the field observations




6. Mapping of soils that is identification and delineation of different kinds of soils based on field and laboratory studies supported by conditions like landforms, climate and natural vegetation on a standard topographical base map.





7. Interpretation and reporting

- A soil map may contain several map units which are shown in the legend or key.
- The legend describes different soils and is basic for understanding mapped soils.
- Once the soil map is ready, the next step is to develop:
    i) Soil survey interpretation for making predictions about the problems and potential of different soil map units for alternative uses such as crops, grasses, fruit or forestry, plantation, etc.
    ii) Management needs for sustainable agricultural production and planning.
    iii) Transfer of technology from research stations to farmers' fields by correlating the characteristics of soils of known behavior and predicting their adaptability to various uses and productivity under defined set of management practices.

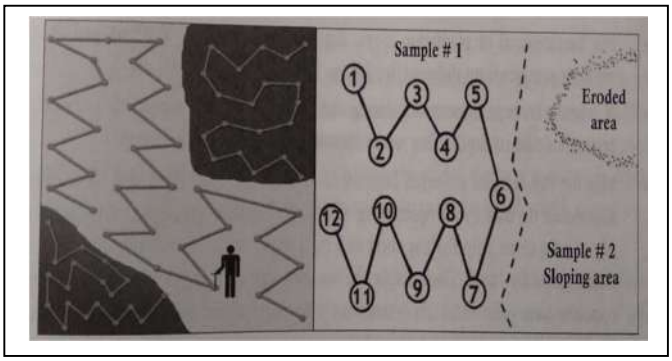
Skill Set (SSAC) 9: Soil sampling

Introduction

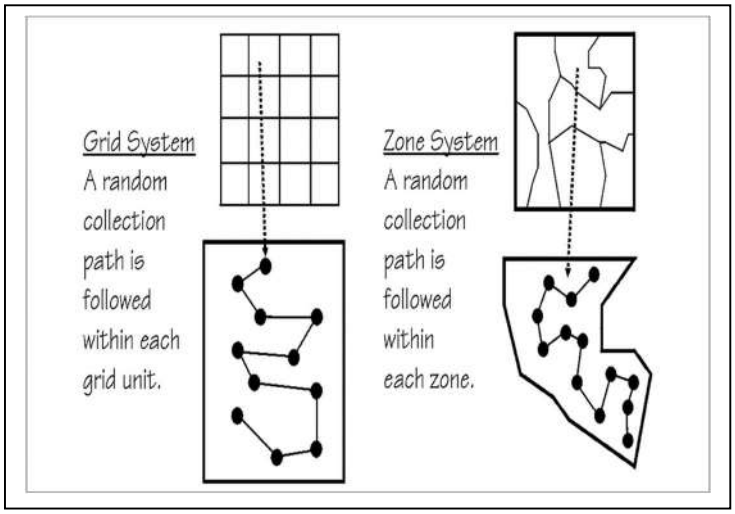
Soil sampling is a technique by which a truly representative sample of a given area is collected. A small error committed in soil sampling will be magnified in the analysis. The first step in the soil testing programme is to obtain a representative soil sample. The collection of representative samples is most important in an effective soil testing programme as the entire analysis and recommendation depends on the sample collected.

Procedure:

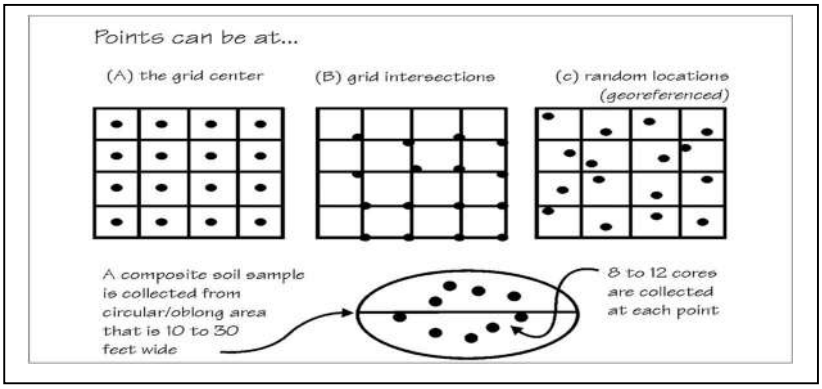
i) The zigzag pattern of soil sampling is shown below:



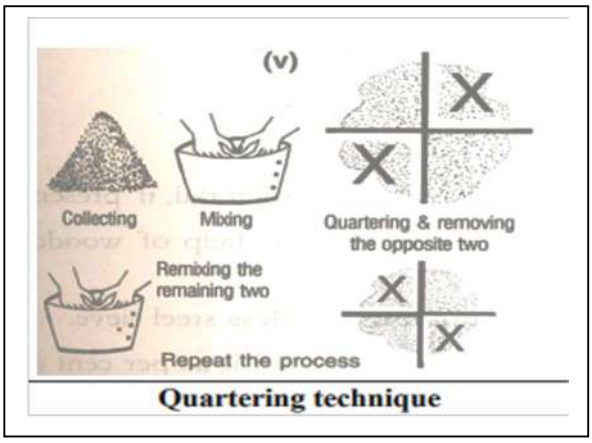
ii) The grid method of soil sampling is shown below:



iii) Collection of representative soil sample through grid method is shown below:



iv) Quartering technique to get right soil sample for analysis



Precautions to be taken during soil sampling:

a) Avoid collecting soil sample near bunds, near roads, near FYM/ compost pits, below the trees, near buildings, near nalas/ streams/ ponds/ wet spots, irrigation canals and drainage lines and other unrepresentative spots.

b) Do not collect soil samples immediately after the application of fertilizers, manures, and amendments. There should be a minimum 3-month gap after the application of fertilizer manures and amendments.

c) If the soil sample has to be analyzed for micronutrients, avoid tools made of iron, copper, and brass. Use only stainless steel, wooden, aluminium, and plastic tools.

d) If the soil sample is moist, dry it under shade before sending it to the laboratory and avoid drying near fertilizer/chemicals/pesticides godowns.

e) All sampling tools and storage bags should be perfectly clean to avoid contamination.

Skill Set (SSAC) 10: Biofertilizer production technology

Principle:

Biofertilizers are formulations containing living or dormant cells of effective strains of microorganisms, that help crop plants' uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil. They accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants.

Equipments required:

i) Autoclave, ii) Laminar Air Flow, iii) BOD Incubator, iv) Hot Air Oven, v) Refrigerator, vi). Fermentor, vi) Weighing balance, vii) pH meter

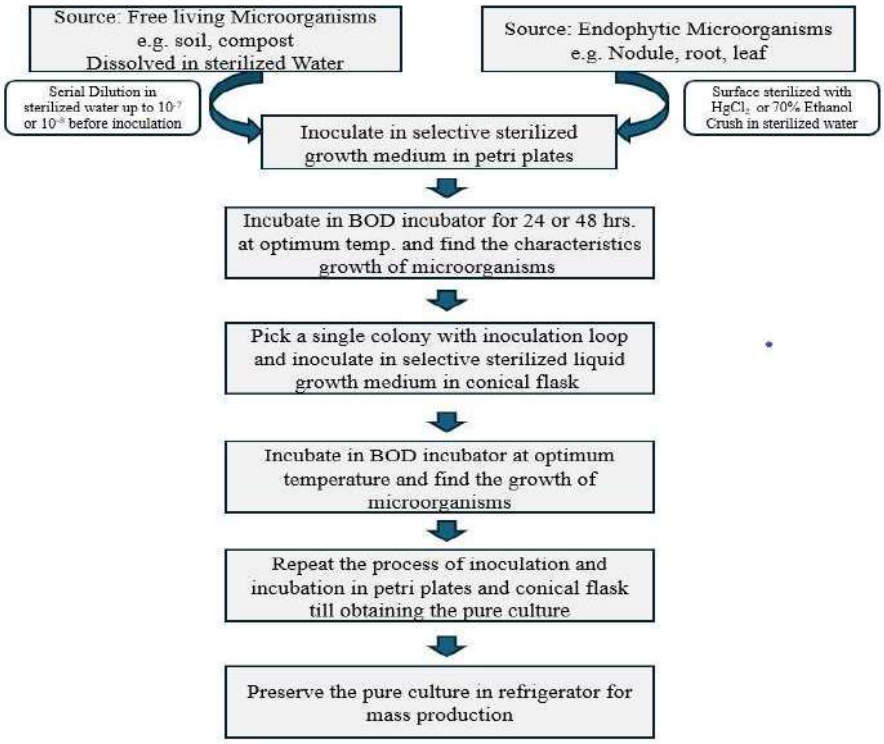
Glassware and other necessary materials required:

i)Petri dishes for holding molten media, ii) Test tubes or culture tubes, iii) Micro-pipettes, iv) Spreaders, v) Spreaders, vi) Inoculation loop, vii) Bunsen burner, viii) Measuring cylinders, ix) Conical flasks, x) Beakers

Mass production Technology for biofertilizer production

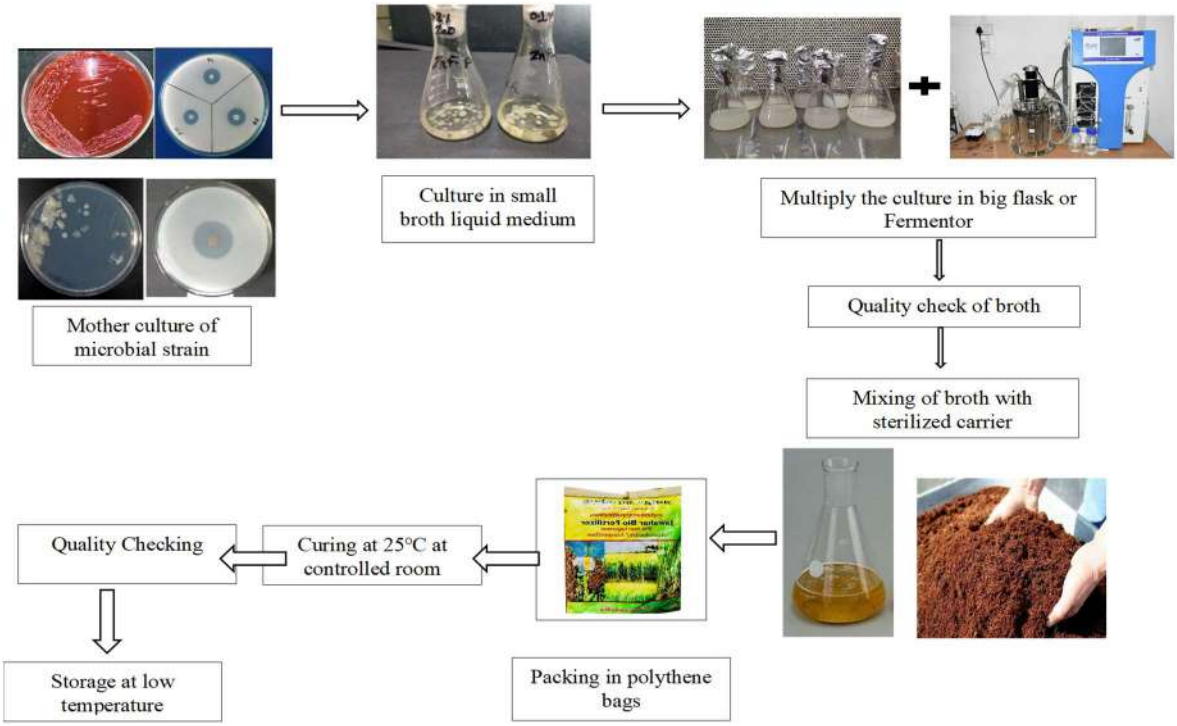
For the successful and efficient preparation of biofertilizers, it is essential to isolate authentic strains of desired beneficial microorganisms from various probable habitats such as soil, compost, water, and even plant surfaces for free-living microorganisms, as well as plant root nodules, leaves, flowers, and fruits for endophytic microorganisms. The mass production of carrier based bacterial biofertilizers involves three stages.

- Culturing of microorganisms
- Processing of carrier material
- Mixing the carrier and the broth culture and packing



Isolation of microbial strain

Inoculum preparation for mass production: Schematic representation of mass production of bacterial biofertilizers



Storage of bio-fertilizer packets:

- The packet should be stored in a cool place away from the heat or direct sunlight.
- The packets may be stored at room temperature or in cold storage conditions in lots in plastic crates or polythene / gunny bags.
- The population of inoculant in the carrier inoculant packet may be determined at 15 days interval. There should be more than 10^9 cells / g of inoculant at the time of preparation and10^7 cells/ g on dry weight basis before expiry date.

Skill Set (SSAC) 11: Determination of organic carbon in soil by dichromate wet oxidation method

Principle:

The organic matter in the soil gets oxidized by with a mixture of potassium dichromate and concentrated H_2SO_4, utilizing the heat of dilution of H_2SO_4. The excess of potassium dichromate, not reduced by the organic matter of the soil, is determined by titration using ferrous ammonium sulphate (FAS) solution in the presence of phosphoric acid using diphenylamine as indicator.

Apparatus:

Conical flasks, pipette, burette, measuring cylinder, weighing balance

Reagents Preparation:

1. **1 N Potassium Dichromate**

   Dissolve 49.04g of AR grade $K_2Cr_2O_7$ in distilled water and make the volume to one liter.


2. **Conc. Sulphuric acid (H_2SO_4)**

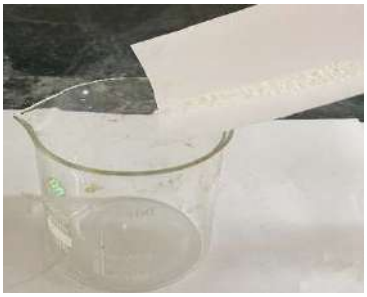
3. **0.5 N Ferrous Ammonium Sulphate (FAS)**

   Dissolve 196 g of FAS in distilled water, add 20 ml of conc. H_2SO_4 and make volume to one litre


4. **Diphenylamine Indicator**

   Dissolve 0.5g of the dye in a mixture of 20 ml of distilled water and add 100 ml of conc. H_2SO_4.





5. **Orthophosphoric acid (85%)**

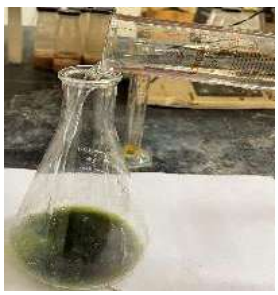
Procedure:

- Weigh 1g (0.2 mm sieved) soil sample into 500 ml dry conical flask

Add 10 mL of 1N $K_2Cr_2O_7$ and 20 mL of conc. H_2SO_4 with little swirling during addition

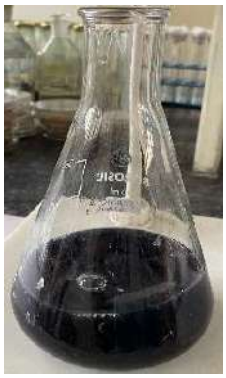
- Leave the flask for 30 minutes without disturbing so as to cool the contents and to make the reaction complete.

- Add slowly 200 ml of distilled water and 10 ml of orthophosphoric acid



- Add 1 ml of diphenylamine indicator, which will give a deep violet colour of the suspension will appear.

- The contents are titrated with 0.5 N ferrous ammonium sulphate solution in 50 mL burette till the colour changes from violet to bright green colour starts appearing.
- Note the volume of the ferrous ammonium sulphate solution used in titration and calculate the results as given below (If the titre value is <6, repeat taking 0.2 to 0.5 g of soil sample).



Calculations

$$\text{Organic carbon in soil} = \frac{(X-Y) \times 0.003 \times 100}{2 \times W} = Z\ (\%)$$

Where,

W = Weight of soil taken (g)
X = Volume of 0.5 N ferrous ammonium sulphate used for the blank titration
Y = Volume of 0.5 N ferrous ammonium sulphate used for titrating the excess $K_2Cr_2O_7$
Organic carbon in soil (%) = Z × 1.3 = R

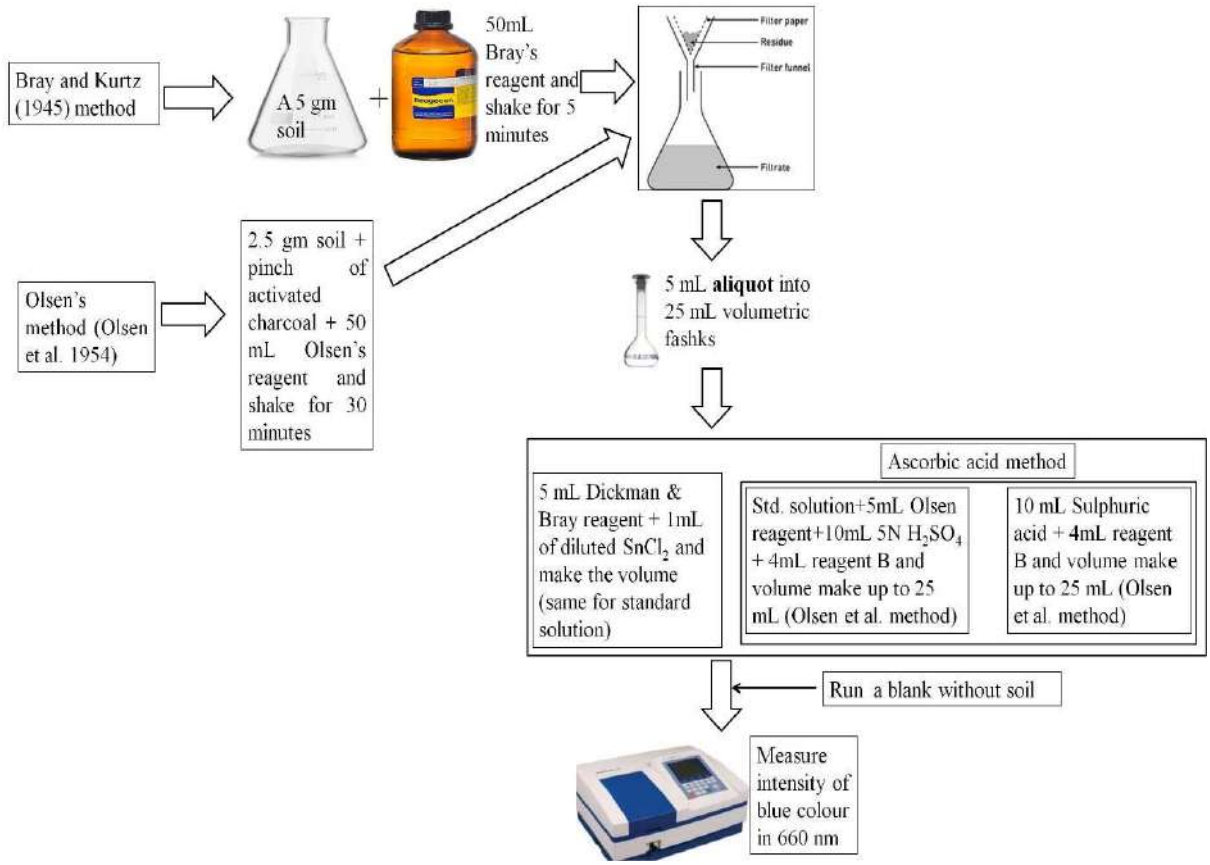
There is incomplete oxidation of organic matter in this procedure. The organic matter is multiplied by 1.3 on the assumption that there is 77% recovery.

Skill Set (SSAC) 12: Determination of soil available phosphorous (p) content

Principle:

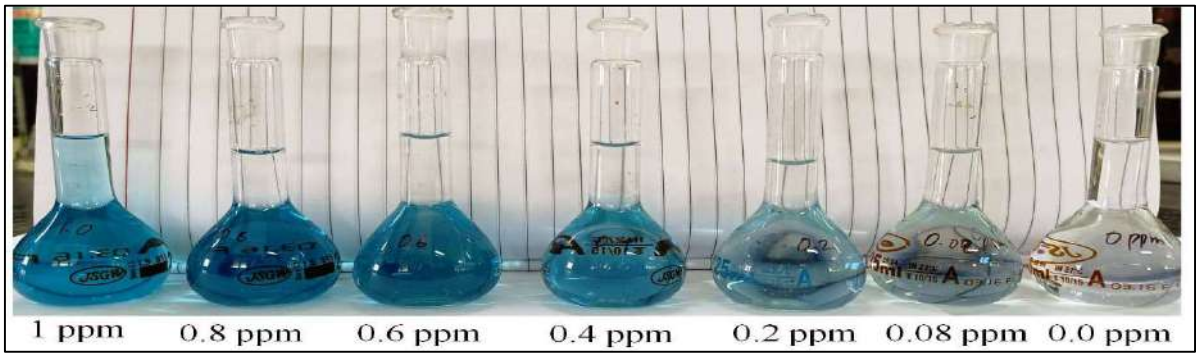
The phosphorous (P) complexes with Al and Fe in the soil as bound P and easily acid soluble P which is extracted using suitable extractant. For acidic soil, phosphorous is extracted with Bray's reagent (0.03 N NH_4F + 0.025N HCl) and Olsen reagent (0.5M $NaHCO_3$ pH 8.5) for saline and alkali soil.

Procedure:



Standard phosphorous solution:

- 100 ppm P stock solution: Dissolve 0.439 gm of KH_2PO_4 in 500 ml of distilled water + 25 ml of 7N H_2SO_4 and make up to 1L volume. Dilute a suitable volume of 100 ppm solution by 50 times to get 2 ppm solution.
- Pipette out 0, 1, 2.5, 5, 7.5, 10, and 12.5ml of 2 mg P/L solution in 25 mL volumetric flasks gives 0, 0.08, 0.2, 0.4, 0.6, 0.8, 1ppm.



Reagents

Bray reagent: Dissolve 1.11 g of ammonium fluoride in distilled water + 2.1 ml concentrate HCl. Dilute to 1L with distilled water.

Olsen reagent (0.5M $NaHCO_3$ pH 8.5): Dissolve 42g of sodium bicarbonate in 500 ml of distilled water and dilute to 1L. Adjust pH 8.5 using NaOH solution or dilute HCl.

Dickman and Bray's reagent (1.5% solution of ammonium molybdate in the HCl): Dissolve 15 g of ammonium molybdate in 300 mL warm water, cool + 34.2mL concentration HCl and make up the volume to 1L.

40% $SnCl_2$ stock solution: Dissolve 10 g of $SnCl_2$ + 25 ml concentrate HCl by heating. Cool and store in an amber-coloured bottle in the dark with the addition of a small piece of Zn or tin metal to prevent oxidation. Dilute 0.5 ml of $SnCl_2$ solution (40%$SnCl_2$) to 66 ml.

Activated charcoal

Ascorbic acid method

Reagent A: Dissolve 12g ammonium paramolybdate in 250ml distilled water + 0.2908 gm potassium antimony tartrate in 100 ml distilled water + 1L 5N sulphuric acid (i.e., 141 ml concentrate sulphuric acid in 1L distilled water). Final volume makes up to 2L.

Reagent B: Dissolve 1.056 gm ascorbic acid in 200 ml Reagent A.

Calculation

$$\text{Available P (kg/ha)} = \frac{\text{P conc. from the curve x Volume of Extractant (ml) x 2.24}}{\text{Aliquot (ml) x weight of Soil (g)}}$$

Skill Set (SSAC) 13: Preparation of Jeevamruth

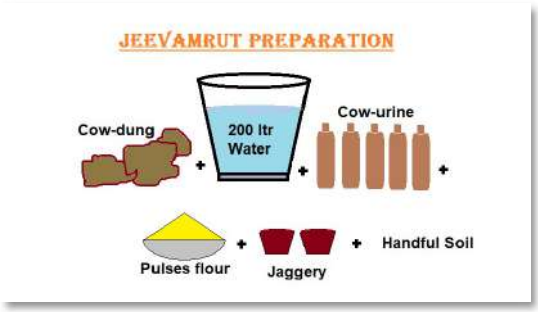
Objectives: To improve soil fertility with macro and micronutrients

Procedure:

1. Collect raw material required for the preparation of 10kg cow dung, 5 kg cow urine, 2 kg Jaggery, 2 kg pulses flour,100 g good soil and 200 litre of water.
2. Take 200 litre of water in barrel.
3. Take 10 kg local cow dung and 5-10 litre cow urine and add it in water.

4. Add 2 kg jaggery (Gud), 2 kg pulses flour and handful soil from the bund of the farm in barrel.
5. Then stir the solution well and keep it for 48 hours in the shadow. The mixture needs to be stirred couple of times for minimum 10 minutes. It gets fermented. After 48 hours Jeevamruth is ready to use. It can be used for 2-3 days.

After 8 days of preparation, bacteria start reducing which are present in liquid jeevamruth.



Methods of application

Concentrated jeevamruth can be applied to the soil, plants, spray and seed treatment in different crops.

In liquid Form – Spray 5-10% of jeevamruth in water. For an acre, 100-200 litre of jeevamruth is needed. It is beneficial if it can be used once at intervals of 7-10 days.

In Solid Form (Ghanjeevamruth) – Spread directly to the field. It can be used for 6-8 months.

SOCIAL SCIENCE (AGRICULTURAL ECONOMICS)

Skill Set (Agri. Econ) 1: Preparation of balance sheet

Balance sheet:

It is also known as a net worth statement. It is a summary of assets, liabilities, and owner's equity (net worth) at a given point in time. This statement shows the value of assets that would remain if the farm business is liquidated and all the outside claims against the business are paid. A business is considered solvent if the value of assets exceeds debt level. It is very useful for the lender to scrutinize the loan application. It shows a snapshot of your business at a point in time and accumulates over the lifetime of a business. It also shows the net worth of your business. The term "balance" implies that the value of assets must equal the value of liabilities plus owner's equity or net worth.

The balance sheet always balances

ASSETS – LIABILITIES = EQUITY or Assets = Liabilities + Net worth (Equity)

The objective of Preparing a Balance Sheet

It is important to understand why we should have a balance sheet, whether we are a business owner or just establishing one. Balance sheets can be used to:

- Showcase the company's current financial situation.
- Keep a record of the debits and credits.
- Assess the worth and status of all assets and liabilities.
- Determine the amount of capital owing to the owner at the end of the financial year.
- Use as a reference if there is a need for a loan.
- Understand the company's liquidity pattern and profit/loss status.
- Evaluate the business's strengths and shortcomings and use them as a guideline for developing policies and goals for the company.

Steps for preparing a Balance Sheet

Step 1: Determine the balance sheet date and period

A balance sheet is intended to display all of the company's assets, liabilities, and shareholders' equity on a single day of the year or throughout a specified period. The majority of businesses, particularly those that are publicly listed, will report every quarter. When this is the case, the reporting date is normally the last day of the quarter. Companies may alternatively opt to generate monthly balance sheets; in which case they would report on the last day of each month. Companies that report on an annual basis will often select December 31st as their reporting date, however, any date can be used.

Step 2: Determine the Assets

After determining the reporting date and period, all assets should be total as of that date and period. To make this section more actionable, arrange them in order of liquidity. More liquid assets, such as cash and accounts receivable, are prioritized, whereas illiquid assets, such as inventories, are prioritized last. After listing the current assets, we need to mention the non-current (long-term) ones. Remember to list non-monetary assets as well.

Step 3: Determine the Liabilities

After the description of numerous asset categories, similarly, we must identify liabilities. Then, list current liabilities, which include Accounts payable, Accrued costs, and Deferred income. After listing current liabilities, we must include non-current liabilities, such as deferred revenue and long-term debt.

Step 4: Determine Shareholders' Equity

Determine the company's retained earnings, working capital, and total shareholders' equity. This computation may get more complex if it is publicly traded, depending on the different forms of shares issued. This area of the balance sheet contains common line items such as common stock, preferred stock, and so on.

Step 5: Make the sum of total liabilities and total Shareholders' Equity and compare it to Total Assets

To ensure the balance sheet is balanced, total assets must be compared to total liabilities plus equity. To do so, sum the liabilities and shareholders' equity together. We have done the balance correctly if our liabilities + equity = assets. If not, we may need to go back and evaluate our sheet.

Skill Set (Agri. Econ) 2: Estimation of cost of crop production and livestock enterprise using CACP concepts

COST CONCEPTS

The cost concept in economics tells us how expensive it will be to carry out the production of a certain good or service. A firm uses various inputs for the production of goods and services. The firm has to make payments for such inputs as they are not free. The expenditure incurred on these inputs is known as the cost of production in economics. The concept of cost in economics refers to the total expenditure incurred in producing a commodity. In economics, cost is the sum total of – explicit cost and implicit cost.

1. **Explicit Cost –** Explicit cost refers to the actual money expenditure on inputs or payment made to outsiders for hiring their factor services. Explicit cost is also known as accounting cost. For example, wages paid to the employees, rent paid for hired premises, payment for raw materials, etc.

2. **Implicit Cost –** Implicit cost is the estimated value of the inputs supplied by the owners including normal profit. For example, interest on own capital, rent of own land, salary of including normal entrepreneur, etc. Such costs are the costs of self-supplied factors.

So, the concept of cost in economics includes actual expenditure on inputs (i.e., explicit cost)

and the imputed value of the inputs supplied by the owners (i.e. implicit cost). The economic cost of production includes not only the accounting cost, which is the explicit cost, but the imputed value, which is the implicit cost also. The sum of explicit cost and implicit cost is the total cost of production of a commodity. Both Explicit Cost and Implicit cost together constitute Economic Cost.

Fixed Costs (FC): FC includes interest on fixed capital and depreciation. The interest on fixed capital was worked out at the prevailing interest rate given by the commercial bank in the study area.

Variable Costs (VC): VC are those costs that are incurred on the variable factors of production and can be altered in the short run. It included seed cost, labour cost, manure and fertilizers cost and cost of plant protection chemicals.

It was obtained by adding all the cost components including fixed and variable costs.

Gross Cost = Total Variable Cost + Total Fixed Cost

Costs and Returns Concepts

To estimate the cost of cultivation following cost concepts were used (CACP):

Cost A_1 = Value of purchased material inputs (seed, insecticides and pesticides, manure, fertilizer) + hired human labour + animal labour (hired and owned) + hired farm machinery + depreciation on farm implements and farm buildings + irrigation charges + land revenue cesses and other taxes + interest on working capital.

Cost A_2 = Cost A_1 + rent paid for leased-in land.

Cost B_1 = Cost A_2 + interest on value of owned capital assets (excluding land).

Cost B_2 = Cost B_1+ rental value of owned land (minus land revenue).

Cost C_1 = Cost B_1 + imputed value of family labour.

Cost C_2 = Cost B_2 + imputed value of family labour.

Cost C_3 = Cost C_2 +value of management input at 10 per cent of total cost

For returns analyses the following measures were used.

Gross returns = Value of the main product + by product

Farm business income = Gross income – Cost A_2

Family labour income = Gross income – Cost B_2

Net income = Gross income – Cost C_2

Farm investment income = Farm business income – Wages of family labour

Return per rupee (RPR) = $\frac{\text{Gross income}}{\text{Total Cost}}$

Imputation methods

Sl. No.	Items	Criteria
1	Family labour	Based on statutory wage rate or the actual market rate whichever is higher.
2	Owned animal labour	Based on cost of maintenance which includes the cost of green and dry fodder and concentrates, depreciation on animal and cattle shed upkeep labour charges, and other expenses.

3	Owned machinery charges	Based on the cost of maintenance of farm machinery which includes diesel, electricity, lubricants, depreciation, repairs and other maintenance expenses.
4	Implements	Depreciation and charges on account of minor repairs
5	Farm produced manure	Evaluated at rates prevailing in the village
6	Rent of owned land	Estimated on the basis of prevailing rents in the village for identical type of land or as reported by the sample farmers subject to the ceiling of fair rents given in the land legislation of the concerned state.
7	Interest on owned fixed capital	Interest on present value of fixed assets charged at the rate of 10% per annum

Allocation/Apportion of Joint Costs

The expenditure incurred on or imputed for some of the cost items relate to the farm as a whole. Such joint costs are allocated to individual enterprises among different categories of livestock and so on. Depreciation of farm buildings and implements, land, rents, land revenues and taxes, interest on owned fixed capital are such costs which are allocated to each category of crops in proportion to their areas. The costs on livestock are allocated to each category of animals in proportion of its numbers to the total number of animals owned by the farmer.

The apportionment of total costs incurred jointly on different crops grown in mixture crops is done in proportion to the total value of output contributed by individual crops in the crop mixtures. The apportionment of total costs of cultivation between the main product and the by products is done in proportion to their contribution to the total value of output.

Sl no.	Asset	Criteria
1	Owned and self-cultivated land	Evaluated at rates prevalent in the village, taking into account the differences in type of soil, distance from the village, source of irrigation available etc.
2	Farm buildings (cattle sheds, storage sheds etc.)	Evaluated at rates prevailing in the village
3	Implements and other farm machinery	Evaluated at market prices
4	Livestocks	Evaluated at market prices

Example: Estimate the cost of cultivation for lemon using cost concept.

Table: Cost of cultivation for Lemon

Particulars	**Total cost (**₹/ha)
Hired labour	6495.52
Planting material (seedlings)	4112.03
Interest on working capital@ 4%	424.30
Depreciation	10581.78
Cost A1	21613.64
Rent paid for lease in land	0.00

Cost A2	21613.64
Interest on value of owned fixed capital assets	7021.68
Cost B1	28635.32
Rental of owned land less land revenue+ rent paid for leased in land	35000
Cost B2	63635.32
Value of owned labour	34666.32
Cost C1	63301.31
Cost C2	98301.31
Cost C3	108131.44

From the above Table we can conclude that the cost of cultivation for lemon is ₹108131.44/ha.

Skill Set (Agri. Econ) 3: Farm planning

A Farm Plan is a scheme for organizing a farm business. An ideal farm plan satisfies all the resource constraints of a farm and yields maximum profit. A farm plan is a programme of the total farm activities of a farmer drawn out in advance. An optimum farm plan will satisfy all the resource constraints at the farm level and yield the maximum profit.

FARM PLANNING

Farm planning is a process of allocating available scarce resources the farm to organize farm production in such a way that it increases resource use efficiency and increases income and employment of the farmers. Farm planning has the following advantages

- It examines existing resource situation
- Identify various supply needs for existing and improved farm plan
- Find out credit needs
- Get an idea of expected outcome
- Provide cash income at the point of time when they may be needed at the farm

Farm planning is a decision-making process in the farm business, which involves the organization and management of limited resources to realize the specified goals continuously. Farm planning involves selecting the most profitable course of action from among all possible alternatives.

Objectives of Farm Planning

The ultimate objective of farm planning is to maximize the annual net income sustained over a long time period.

The farm planning helps the cultivator in the following ways:

a) It helps him examine carefully his existing resource situation and past experiences as a basis for deciding which of the new alternative enterprises and methods fit his situation in the best way.

b) It helps him identify the various supply needs for the existing and improved plans. c) It helps him find out the credit needs, if any, of the new plan.

d) It gives an idea of the expected income after repayment of loans, meeting the expenditure on production, marketing, consumption, etc.

e) A properly thought-of farm plan might provide cash incomes at points of time when they may be most needed at the farm.

Type of Farm Plan:

Simple Farm Plan: Simple farm plan implies planning for minor changes or for a particular enterprise.

Complete Farm Plan: Complete farm planning envisages a greater number of changes in the existing organization. It is adopted for the farm.

Components of Farm Planning

Any systematic farm planning necessarily has the following five components:

1) Statement of the objective function: Many farmers aim at profit maximization. However, some farmers do not go all out to maximize their profits but have objectives like cereal requirements for the family and fodder needs for the livestock.

2) Inventory of scarce resources and constraints

a) Land: Location, topography, soil type, fertility, drainage, irrigation systems and so on affect enterprises in many ways and hence, it is useful to divide all the land on a farm into different enterprises.

b) Labour: On subsistence farms, all labour is supplied by the farmer and his family. Thus, it is important to record the number of workers - male, female and children - and the type of manual work each is prepared is undertake. However, in commercial farms, hired labour constitutes a major component of costs and thereby inviting more attention in the planning process.

c) Capital: Whether fixed, like buildings and machines, or circulating, like cash in hand or in the bank, capital acts as a very powerful constraint.

d) Personal: Farmers' experience, attitude towards risks and uncertainties, and personal likes and dislikes influence the choice of enterprise.

e) Institutional: Market often serves as a constraint for the production of vegetables, poultry, milk, etc. Even if the location of the farm is suitable for a particular crop (commodity), a contract may still have to be obtained. E.g. Sugarcane growing near the sugar mills. Similarly, though many parts of Himachal Pradesh are suitable for poppy cultivation, the government has banned its cultivation.

f) Rotations: Maximum permissible area under a particular crop in a given season or minimum area constraints imposed on the acre under some crops like legumes would serve in maintaining soil fertility and help control pests and diseases.

3) Alternative Choices: Choices in planning refer to the various enterprises, crops and livestock, which can be considered for attaining the stated objectives. There are alternate ways to use the scarce farm resources. There may be more than one way to produce the same enterprise. A comprehensive list of different alternative enterprises can be prepared.

4) Input Output Co-efficient: The requirements of each of the several scarce resources and the financial returns per unit of each enterprise or activity need to be considered here. The precision in planning depends more on accurate input-output data than on the technique of planning.

5) Planning Technique: With a proper understanding of the planning environment and use of precise input-output data along with true and realistic constraints, sophisticated techniques give better results. However, common sense in the planning process could lead to fairly good results. Some of the farm planning techniques are as listed below:

1. Budgeting

2. Linear Programming. Budgeting is most informal of all the planning techniques and the level of sophistication gradually increases as we move from budgeting to linear programming.

Steps of farm planning

1. • Prepration of Farm Map
2. • Recording of history of farm
3. • Planning for labour and Farm machninaries
4. • Planning for land use and soil conservation practice
5. • Planning form livestcok programme
6. • Planning for marketing of Produce

Farm Layout: It gives farmers a clear view of what is being fixed according to land convenience and economy for various purposes on the farm. The crop planning, farmhouse, irrigation channel/pipe, road, electricity pole, Livestock shed, bore well, storehouse etc. The preparation of the farm layout and development of the farm accordingly long run is a strategic decision that is to be taken by the Farm business owner. While designing the farm layout following points are to be taken into consideration-

General design of a Multi-Purpose Farm (Lim 2007)

Characteristics of a Good Farm Plan

a) An element of flexibility in a farm plan is essential to account for changes in the environment around the farm.
b) A farm plan should maximize the resource use efficiency at the farm.
c) It should provide for the attainment of the objectives of profit maximization through optimum resource use and balanced combination of farm enterprises.
d) Risk and uncertainty can be accounted for in a good farm plan.
e) The plan helps in timely acquisition and repayment of farm credit

Skill Set (Agri. Econ) 4: Farm budgeting

The expression of a farm plan in monetary terms by estimation of receipts, expenses, and net income is called budgeting. Farm budgeting is a process of estimating the costs, returns, and net profit of a farm or a particular enterprise. A budget is a statement of estimated income and expenditure.

Objectives:

1. To serve as the basis of farm plan preparation and its evaluation.
2. To help farmers adopting such farming methods in meeting market demands which can give higher returns on their investment

Types of Farm Budgeting:

a) Whole Budget/ Complete Budgeting/Total Budgeting Method: The whole farm budget is a quantitative expression of the total farm plan summarizing the income, costs, and profit. Income is what the farmer realizes from farming activities, costs are what the farmer put into production and profit is the difference in income and cost. In complete farm budget unit of analysis is whole farm. Complete budgeting can be prepared for the short run (annual budget) and long run.

b) Enterprise budget: An enterprise is a single crop, livestock, pig, poultry fishery, bee-keeping unit etc. An enterprise budget lists all income and costs of a specific enterprise and provides profit of that enterprise. The enterprise budget is estimated on a per hectare or per unit basis. Enterprise Budget helps in comparing the profit of two or more enterprises of the same farm or different farms.

c) Partial Budgeting: Partial budget shows the effect of change in farm operation. Suppose a farmer has the option of adopting a new variety of paddy. Then partial budgeting is to be used to evaluate total gain, total loss, and net gain from the new variety over the existing variety of paddy and if it is found that net gain is positive then the farmer can decide in favour of adopting new varieties. Similarly partial budgeting can be used for the following changes-

- Substituting one enterprise for other enterprises
- Changing different levels of a single technology
- Changing different technology

Complete Budgeting	Partial Budgeting
i. The whole farm is considered as one unit. ii. All the aspects like crops, livestock, machinery, and other assets are considered. iii. Both fixed and variable costs are calculated for working out costs and returns. iv. Net income is estimated by deleting fixed costs and cost of variable inputs from the value of the product. v. It requires more effort and time for preparation.	i. It is adopted when a minor aspect of farm organisation is touched. ii. It is practiced with in the existence resources structure of the farm. iii. Only variable cost is considered. iv. Net income is estimated by deleting only cost of variable inputs from the value of the product. v. It requires relatively less effort and time for preparation.

Advantages of Farm Budgeting:

(a) It evaluates the old plan and guides the farmers to adopt a new farm plan with advantages.

(b) It makes the farmer conscious of the waste (leakage) in the farm business.

(c) It gives a comparative study of receipts, expenses, and net earnings on different farms in the same locality and different localities for formulating national agricultural policies.

(d) It guides and encourages the most efficient and economical use of resources.

(e) It serves as a valuable basis for improvements in farm management practices.

Skill Set (Agri. Econ) 5: Producer's surplus for agricultural commodities

Producer's Surplus: The Producer's Surplus is the quantity of produce which is or can be made available by the farmers to the non-farm population.

Types of producer's surplus

The producer's surplus is of two types:

1. **Marketable Surplus:** The marketable surplus is that quantity of the produce which can be made available to the non-farm population of the country. It is a theoretical concept of surplus. The marketable surplus is the residual left with the producer-farmers after meeting his requirement for family consumption, farm needs for seeds and feed for cattle, payment to labour in kind, payment to artisans, blacksmith, potter and mechanic payment to landlord as rent and social and religious payments in kind. This may be expressed as follows:

$$MS = P - C$$

Where,

MS = Marketable surplus

P =Total production, and

C = Total requirements (family consumption, farm needs, payment to labour, artisans, landlord and payment for social and religious work)

2. **Marketed Surplus**: Marketed surplus is that quantity of the produce which the producer farmer actually sells in the market, irrespective of the requirements for family consumption, farm needs and other payments. The marketed surplus may be more, less or equal to the marketable surplus.

Relationship between Marketed Surplus and Marketable Surplus

The marketed surplus may be **more, less or equal to** the marketable surplus, depending upon the condition of the farmer and type of the crop. The relationship between the two terms may be stated as follows.

$$\text{Marketed Surplus} \gtreqless \text{Marketable Surplus}$$

1. The marketed surplus is **more** than the marketable surplus when the farmer retains a smaller quantity of the crop than his actual requirements for family and farm needs. This is true especially for small and marginal farmers, whose need for cash is more pressing and immediate. This situation of selling more than the marketable surplus is termed as **distress or forced sale**. Such farmers generally buy the produce from the market in a later period to meet their family and/or farm requirements. The quantity of distress sale increased with the fall in the price of the product. A lower price means that a larger quantity will be sold to meet some fixed cash requirements.
2. The marketed surplus is **less** than the marketable surplus when the farmers retain some of the surplus produce. This situation holds true under the following conditions.
    a. Large farmers generally sell less than the marketable surplus because of their better retention capacity. They retain extra produce in the hope that they would get a higher

price in the later period. Sometimes, farmers retain the produce even up to the next production season.

b. Farmers may substitute one crop for another crop either for family consumption purpose or for feeding their livestock because of the variation in prices. With the fall in the price of the crop relative to a competing crop, the farmers may consume more of the first and less of the second crop.

3. The marketed surplus may be **equal** to the marketable surplus when the farmer neither retains more nor less than his requirement. This holds true for perishable commodities and of the average farmer.

Factors affecting Marketable Surplus

The marketable surplus differs from region to region and within the same region, from crop to crop. It also varies from farm to farm. On a particular farm, the quantity of marketable surplus depends on the following factors.

i. **Size of holding**: There is positive relationship between the size of the holding and the marketable surplus.

ii. **Production**: The higher the production on a farm, the larger will be the marketable surplus and vice versa.

iii. **Price of the Commodity**: The price of the commodity and the marketable surplus have a positive as well as a negative relationship, depending upon whether one considers the short and long run or the micro and macro levels.

iv. **Size of family**: The larger the number of members in a family the smaller the surplus on the farm.

v. **Requirement of Seed and Feed**: The higher the requirement for these uses, the smaller the marketable surplus of the crop.

vi. **Nature of Commodity**: The marketable surplus of non-food crops is generally higher than that for food crops. For example, in the case of cotton, jute and rubber, the quantity retained for family consumption is either negligible or very small part of the total output. For these crops, a very large proportion of total output is marketable surplus. Even among food crops, for such commodities like sugarcane, spices and oilseeds which require some processing before final consumption the marketable surplus as a proportion of total output is larger than that for other food crops.

vii. **Consumption Habits**: The quantity of output retained by the farm family depends on the consumption habits, for example, in Punjab, rice forms a relatively small ptoportion of total cereals consumed by farm-families compared to those in southern or eastern states. Therefore, out of a given output of paddy/rice, Punjab farmers sell a greater proportion than that sold by rice eating farmers of other states.

The functional relationship between the marketed surplus of a crop and factors affecting the marketed surplus may be expressed as:

$$M = f(x_1, x_2, x_3, x_4 \ldots\ldots x_n)$$

Where

M = Total marketed surplus of a crop in quintals

x_1 = Size of holding in hectars

x_2 = Size of family in adult units

x_3 = Total production of the crop in quintals

x_4 = Price of the crop

x_n = Other factors.

Example 1: The information on Basmati paddy crop gathered from the survey of two farmers of Punjab has been given below. Comment on the relationship between marketable and marketed surplus of both the farmers for paddy.

Particulars	Area (ha.)	Productivity (qt./ha.)	Family consumption (qt.)	Seed purpose (qt.)	Wages in kind (qt.)	Quantity sold (qt.)
Farmer A	10	45	13.45	9.30	22.50	300
Farmer B	05	43	17.80	6.00	30.30	170

Solution:

Particulars	Farmer A	Farmer B
Area (ha.)	10	5
Productivity (qt./ha.)	45	43
Total production (qt.)	10 x 45 = 450	5 x 43 = 215
Total requirement (qt.)	13.45 + 9.30 + 22.50 = 45.25	17.80 + 6 + 30.30 = 54.10
Marketable surplus (qt.)	450 – 45.25 = 404.75	215 – 54.10 = 160.90
Marketed surplus (qt.)	300	170

- In case of Farmer A, the marketed surplus is less than that of marketable surplus, which indicates no signs of distress sales. The farmer have retained 104.75 qt. (404.75 – 300) of paddy.
- In case of Farmer B, the marketed surplus is more than the marketable surplus, which indicates that Farmer B must have sold a part of paddy (170-160.90 = 0.10 qt.) from his own consumption requirements. This is the case of distress sale.

Skill Set (Agri. Econ) 6: Project appraisal techniques

Project appraisal technique: Project appraisal technique gives details of cost and return of the proposed business. It involves investment of huge amount of capital. There are different project appraisal techniques but the most common one is investment analysis or capital budgeting. With this, we can evaluate economic feasibility of different projects.

For this, number of information are required like, annual cash revenue, total cost of the project, terminal salvage value, discount rate or interest rate

Methods of Project Appraisal:

Broadly there are two methods of project appraisal or analysis or evaluation namely undiscounted and discount techniques.

Undiscounted cash flow measures of project appraisal:

Undiscounted measures are primitive, which often mislead in ranking of the project leads to wrong choices. Two important measures under this are 1. Pay back period 2. Rate of return method

Pay Back Period (PBP):

The length of time required to get the total investment made on the project is called pay back period. When two projects have same rate of return and the same account of risk, the decision may be taken on the basis of PBP.

P= I / E Where, P= Pack back period
I=Investment made on the project in Rs.
E=Annual net cash revenue in Rs.

Decision rules of PBP:

1) Give highest ranking to the business investment / project which has shorter PBP, and follow ranking in descending order of PBP.
2) Give lowest ranking to the business investment which has longer PBP.
3) Generally, the business investment / project with minimum or shorter PBP i. e. highest rank is accepted first for investment.

Limitation of PBP: It is inadequate to exercise the option among the alternatives, because it fails to consider very important points like consistency of running, timing of the proceeds, returns after the payback period and whether the cash-flow would be positive or negative in future.

Exercise:

Calculate the pay back period of the following two projects and conclude your result. The initial investment in each project is Rs. 20,000/-

Year	Cash flows	
	Project - A	Project -B
1	5,000	4,000
2	5,000	4,000
3	5,000	4,000
4	5,000	4,000
5	5,000	4,000
6	5,000	4,000

Project A = 20000/5000=4 yearsProject B =20000/4000=5 years
Conclusion: Project 'A' with minimum or shorter PBP, so first rank is accepted for investment.

Rate of Return Method (ROR) or Rate ON Investment Method (ROI):

ROR method expresses the profit generated by the investment as a percentage of the investment. In other words, it is return per rupee of investment or ratio of earnings to investment. Its helps to know the profitability of an investment in the business or generation of returns per rupee of investment and to estimate the profits as percentage of investment.

Procedure:

Step 1: Estimate the average investment which is equal to half of the original investment. Original investment can also be used.
Step 2: Estimate the average annual net earnings over the life of the investment.
Step 3: Calculate the average rate of return by dividing the average annual net earnings or net profit by average investment.
Step 4: Average return per rupee of investment

a. Divide the total returns by the number of years of investment to arrive at the average return per year
b. Divide average return per year with original investment

$$ROR = \frac{\text{Net Profit}}{\text{Original Investment}} \times 100$$

Or,

$$\frac{\text{Average annual profit}}{\text{Average Investment}} \times 100$$

Step 5: Apply the decision rule as follows:

a. Give highest rank to the investment in such a project / business whose ROR is highest.
b. Select the business /project whose investment yields highest ROR or having highest.

Discounted measures of project appraisal:

Cash flows are the yearly net benefits accrued from the project. If they are weighed or calculated by discount rate, they become discounted cash flow. These discounted cash flows are the best estimate to decide on the worth of the projects. From the actual stream of gross benefits, the capital invested plus other working cost are deducted to get the net present value. From that residual the return of capital as well as return to capital are computed. The residual is called the cash flow of the project.

The various discounted measures of project analysis are Net present value (NPV), Benefit cost Ratio (BCR), Internal Rate of Returns (IRR), N/K Ratio, Profitability Index etc.

Among these, Benefit cost ratio (BCR) is most important and commonly used.

Benefit cost ratio (BCR):

It is one of the discounted measures that are used to assess the credit-worthiness of the project. Here we compare the present worth of cost with present worth of cost with present worth of benefits. This ratio is obtained by dividing the sum of the present worth of benefit stream of the project with sum of the present worth of cost stream. The mathematical formula for working out this ratio is given as.

$$\text{B-C Ratio} = \frac{\sum_{t=1}^{n} \frac{Bt}{(1+i)^t}}{\sum_{t=1}^{n} \frac{Ct}{(1+i)^t}}$$

Where,

Bt = the benefit stream i.e. benefit of the project question in t^{th} year
Ct = the cost stream i.e. cost of the project in question in t^{th} year
t = 1 to t years i.e. life span of the project
i = the interest rate or discount rate at which funds are borrowed

Utility of BCR:

1. Helps in selection of investment opportunities.
2. Ranking the project for implementation among various alternatives.

EXTENSION EDUCATION

Skill Set (Agri. Extn) 1: Technical Skills for handling audio-visual AIDS

A) Overhead Projector

1. Keep the projectors on the table with the lens facing the wall or screen.
2. Plug in the power cord and turn on the fan first and then the lamp.
3. Place the transparency over the aperture (glass top) with the bottom of the image towards the screen. Adjust the focus on the screen
4. To get a clear image on the screen focusing is done by turning a focus knob which raises or lowers the projection head.
5. Keep the screen at the suitable place so that no one's view is blocked.
6. If the screen is high, the projected image may have a keystone effect which means the base of the image will be smaller than the top.
7. To avoid keystone effect, raise the front of the projector or slant the screen at the bottom.
8. Arrange and keep all the prepared transparency in proper sequence
9. Stand at one side of the projector and ensure that you are not obstructing the view of the audience
10. Place the transparency on the platform (aperture), and switch on the projector.
11. Shift the audience attention back to you by switching off the projector during changes of transparencies and when you have finished a transparency.
12. Use a pencil as a pointer while pointing to specific portion on a transparency by putting the pencil on the transparency.
13. Avoid pointing to the screen. If a transparency consists of several lines or items, show only one line at a time using masking technique with opaque sheet.
14. Move the opaque material down one line at a time.
15. While writing on the transparency on the OHP do not obstruct the view by your hand.
16. After the session, remove all markings on the transparency with a wet cloth or cotton if it is not required further.
17. After presentation is over, turn off the lamp first and then the fan.

B) LCD Projector

A. How to Connect a Projector to a PC

The projector bag contains the projector, a power cable, and a VGA cable. You are going to need a laptop or any other device that will put a signal out through a VGA port

Step 1. Turning on the projector

1. Remove the projector and the power cable from the bag. Find the "AC In" port on the projector and put the correct end of the power cable into it.
2. Plug the other end of the power cable into the wall outlet or power strip you will be using.

3. Make sure the power switch on the projector is in the correct position. The “Power” LED light will come on once you have completed these steps.

Step 2. Connecting the Laptop to the Projector

1. Find the VGA cable located in the projector bag.
2. Locate the “RGB In” or VGA In” port on the projector and connect one end of the VGA cable to that
3. Connect the other end of the VGA cable to the “VGA Out” port on your laptop or other applicable device.

Step 3. Find the Laptop Signal Using the Projector

1. Turn on your laptop and get logged in.
2. Turn on the projector using the “Standby/On” button on the top of the projector. At this time the projectors main screen will start to be projected
3. To force the projector to search for your laptop's signal press the “Input” button on top of the projector. You should see “Searching…” on the projection screen. Within a few seconds the projector will find the signal and project your desktop to the projection screen.
4. If the projector does not find your laptop’s signal you may have to configure the display settings on the laptop. For Windows 7 you will want to press the Windows key and the P key together. This will bring up a small menu on the screen. Choose “Duplicate” to project your desktop through the projector.

B. Disconnecting the Projector

Step 1. Turning Off the Projector

1. Once you are finished with the presentation you use the projector for press the “Standby/On” button. A message will appear on the projector asking if you are sure you want to turn off the projector. If you are sure you want to turn off the projector press the “Standby/On” button again.
2. The projector has now turned off the lamp, but the fan will still be running. Note: It is important not to disconnect the projector from its power supply until the fan has stopped running. Not doing so may cause serious damage to the projector.
3. While the projector is cooling down it is safe to remove the VGA cable that is also connected to your laptop and place it back into the projector bag.

Step 2. Putting the Projector Away

1. Once the projector’s internal fan has stopped running it is safe to disconnect it from the power supply.
2. Disconnect the power cable from the “AC In” port on the projector.
3. Place the power cable and the projector back into the projector bag.
4. Before returning the projector to Media Services please ensure that all parts that came in the bag when you checked it out are returning with the bag when you drop it off.

Skill Set (Agri. Extn) 2: Participatory rural appraisal (PRA) techniques

Participatory Rural Appraisal (PRA) is a methodology for interacting with villagers, understanding them, and learning from them.

PRA is a means of collecting different kinds of data, identifying and mobilizing intended groups evoking their participation, and also opening ways in which intended groups can participate in decision-making project design, execution, and monitoring.

PRA is a process of participation with the villagers in which rapport-building paves the way for them to perform their analysis and to express themselves whether using 'verbals' like narration or 'visuals' such as making a map. The final product of PRA would differ in output and content depending on several factors. The content is in terms of how the process is established what methods are used and how the analysis progresses.

The principles guiding PRA are discussed below:

(i) Optimal Ignorance

In order to minimize cost and time, the principle of optimal ignorance is applied by the facilitators which means knowing what is worth knowing and knowing enough to serve the purpose and not knowing the rest or not trying to find out more. Associated with this is seeking appropriate impressions or avoiding precision that is not necessary.

(ii) Seeking Diversity

PRA is concerned more with the analysis of differences rather than looking for representativeness of results or data collected.

(iii) Offsetting Biases and Triangulating

PRA aims at offsetting biases by being relaxed and not rushing, listening and not lecturing, probing and not speeding indifferently and looking for participation of rural poor and other weaker sections of rural communities.

Triangulation is cross-checking the data in different ways. This is done through the use of various methods and by using different sources to validate information. It involves conscious, non-random selection in different dimensions such as team composition, units of observation, and PRA methods.

(iv) Listening and Learning, Learning Rapidly and Progressively and Learning through Participation

Knowledge of rural people constitutes the base for socio-economic and agroecological information. They have their experiences, history and culture, their ideas, their priorities and preferences. Listening to rural people helps them in portraying their points of view which otherwise remain unknown. The greater the interaction with rural people in the capacity of a listener rather than a speaker, the greater the learning achieved. The amount of learning can increase progressively with the participation of those who form the subject of inquiry.

The major PRA methods include Semi-Structured Interviews, Do-It-Yourself (DIY), Maps and Models, Transect Walks, Seasonal Diagramming, Ranking and Scoring, Wealth Ranking and Grouping, 'Chappati' or Venn Diagrams, Farm Map, Case Study, Historical Profile, Futures Possible, Time Trends, Mobility Map, Daily Routine Diagram, Pie Diagram, Livelihood Analysis and Flow Diagrams.

Skill Set (Agri. Extn) 3: Practical skills in conducting village surveys with an interview schedule

1. Brief Introduction of the Skill

Conducting village surveys with an interview schedule is a vital skill for researchers, development workers, and policymakers aiming to gather qualitative and quantitative data from rural areas. This skill involves preparing a structured set of questions (interview schedule), conducting face-to-face interviews, and accurately recording responses. The objective is to collect detailed information about various aspects of village life, such as socio-economic conditions, health, education, and agriculture, which can inform policy decisions and development initiatives.

2. Importance of the Skill and Areas of Application

Importance:

Data Collection: Provides firsthand information about village demographics, socio-economic status, and living conditions.

Policy Making: Informs government and NGO interventions tailored to specific village needs.

Resource Allocation: Helps in the effective distribution of resources based on accurate data.

Monitoring and Evaluation: Assists in tracking the progress and impact of development programs.

Areas of Application:

Agricultural Research: Understanding farming practices, crop yields, and issues faced by farmers.

Health Surveys: Gathering data on health practices, prevalence of diseases, and access to healthcare.

Educational Studies: Assessing literacy rates, school enrollment, and educational facilities.

Economic Assessments: Evaluating income levels, employment patterns, and economic activities.

3. Pre-requisites to Conduct the Skill

Essential Tools:

Interview Schedule: Pre-designed set of structured questions.

Pen and Paper: For notetaking and recording responses.

Audio Recorder: Optional, for precise capture of responses (with consent).

Identification: Official ID for credibility and trust.

Notebook/Tablet: For digital data entry (if applicable).

Map of the Village: To plan the survey route and identify key areas.

Personal Preparation:

- Local Language Proficiency: Essential for clear communication.
- Cultural Sensitivity: Understanding local customs and norms.
- Interpersonal Skills: Ability to build rapport and trust with respondents.

4. Preparatory Activities (Planning)

- Define Objectives: Clearly outline the goals of the survey.
- Develop Interview Schedule: Create or adapt a questionnaire relevant to the survey objectives.
- Pilot Testing: Test the interview schedule in a similar setting to identify potential issues.
- Training Team Members: Ensure all team members understand the survey objectives, tools, and ethical considerations.
- Obtain Permissions: Secure necessary permissions from local authorities and community leaders.
- Logistics Planning: Arrange for transportation, accommodation, and other logistics for the survey team.

5. Description of the Procedure to Conduct the Skill

i. Initial Preparation:

- Review the interview schedule and ensure all materials are ready.
- Brief the team on the day's plan and assign specific roles.

ii. Introduction to Respondents:

- Introduce yourself and explain the purpose of the survey.
- Obtain informed consent from the respondents.

iii. Conducting the Interview:

- Follow the interview schedule systematically.
- Ask questions clearly and allow respondents time to answer.
- Probe for more information where necessary without leading the respondent.
- Record responses accurately and legibly.

iv. Closing the Interview:

- Thank the respondent for their time and cooperation.
- Provide any promised incentives or information (if applicable).

v. Data Review:

- Review recorded data for completeness and accuracy.
- Resolve any ambiguities or missing information.

vi. Daily Debrief:

- Conduct a team debrief to discuss any issues encountered and plan for the next day.

6. Outcome

The information gathered through village surveys with an interview schedule includes:

- Demographic Data: Age, gender, household size, etc.
- Economic Data: Income sources, employment status, land ownership, etc.
- Health Information: Common illnesses, healthcare access, nutritional status.

- Educational Details: Literacy rates, school attendance, educational attainment.
- Agricultural Practices: Crop types, farming methods, challenges faced by farmers.
- Social Dynamics: Community structure, social practices, and cultural norms

Skill Set (Agri. Extn) 4: Technical writing skills for leaflets, pamphlets, circular letters, articles for mass media etc.

Technical writing skills in leaflet

Leaflets are an excellent way to communicate specific information quickly and clearly. They can distill essential points into a concise format that is easy for the reader to understand. Printing leaflets is generally inexpensive, especially when produced in bulk. This makes them a cost-effective tool for reaching a wide audience. Leaflets can be distributed in targeted locations where your intended audience is likely to be, such as community centers, events, schools, or specific neighborhoods.

Leaflets can be used for a variety of purposes, including:

- Promoting Events: Informing people about upcoming events, such as fairs, concerts, or community gatherings.
- Educational Information: Providing information on health, safety, or educational topics.
- Business Promotion: Advertising products, services, or special offers for businesses.
- Awareness Campaigns: Raising awareness about social, environmental, or political issues.

A well-designed leaflet can capture the reader's attention and engage them with compelling visuals and concise text. Physical leaflets can also be more engaging than digital content, as people can hold and read them at their convenience. Leaflets can complement online marketing efforts by providing tangible material that reinforces your message. They can drive traffic to your website or social media platforms by including QR codes or URLs. Leaflets can provide detailed instructions, guides, or educational content that the audience can refer to later. This is particularly useful for distributing information that people may need to revisit. A well-designed leaflet can enhance your brand image. Consistent use of branding elements such as logos, colors, and fonts can help in building brand recognition and trust. For local businesses or organizations, leaflets are an effective way to reach the community. They can be handed out in person, included in local newspapers, or left in public places. Preparing a leaflet is a strategic way to deliver targeted, clear, and concise information to a specific audience. It is an effective tool for communication, promotion, and education, offering a tangible method to engage and inform people.

Leaflet: A leaflet is a single sheet of printed material designed to convey specific information on a particular topic. It is usually compact, making it easy to distribute and handle. Leaflets are often given out for free and typically focus on one main idea or issue, providing concise and clear information to the reader.

Preparation of a Leaflet:

Define the Purpose: Clearly identify the main objective of the leaflet. Determine what message or information you want to convey to your audience.

Know Your Audience: Understand who will be reading the leaflet. Tailor the content, language, and design to meet the needs and preferences of your target audience.

Research and Content Development: Gather accurate and specific information on the topic. Ensure the content is clear, concise, and relevant to the audience.

Design and Layout:

Visual Appeal: Use a clean and attractive design to grab attention.

Structure: Organize content logically with headings, subheadings, bullet points, and short paragraphs.

Images and Graphics: Include relevant images, charts, or graphics to support the text and make the leaflet visually appealing.

Drafting: Write a draft of the leaflet, focusing on clarity and brevity. Ensure the key message is prominent and easy to understand.

Review and Edit: Proofread the content for accuracy, clarity, and grammatical correctness. Make necessary revisions to improve the overall quality.

Printing: Choose suitable paper quality and printing options. Ensure the final print is clear and professional.

Distribution: Plan how and where the leaflet will be distributed to reach the intended audience effectively. Consider places like community centers, events, public spaces, or direct mail.

Technical Writing skills in Circular Letters

Circular letters are used to communicate and send the same information to a (large) number of people. They are extensively used in announcing important developments in an institution, organization, official campaigns etc. When writing circulars, here are some important skill set to be associated with.

Key Skill set for writing a Circular Letter

1. **Clear Communication:**

   Clarity: Ability to convey the message in a straightforward and understandable manner.

   Conciseness: Skill in writing succinctly without omitting essential details.

2. **Audience Awareness:**

   Understanding the Audience*:* Knowing the target audience and tailoring the message to their needs and expectations.

   Appropriate Tone: Using a tone that matches the purpose and the audience, whether formal or informal.

3. **Organizational Skills:**

   Structured Writing: Ability to organize content logically, with a clear beginning, middle, and end.

   Prioritization: Skill in highlighting the most important information first.

4. **Attention to Detail:**

   Accuracy: Ensuring all details, such as dates, names, and facts, are correct.

   Proofreading: Ability to spot and correct grammatical errors and typos.

5. **Technical Writing Skills:**

   Formal Writing: Proficiency in writing in a formal style suitable for official communication.

Formatting: Skill in formatting the letter to enhance readability and professionalism.

6. **Persuasive Writing:**

   Engagement: Writing in a way that engages the reader and encourages them to take the desired action.

   Motivation: Ability to motivate and inspire the audience to comply with the instructions or information provided.

7. **Research Skills:**

   Information Gathering: Ability to gather relevant information that needs to be included in the letter.

   Fact-Checking: Ensuring all the information is current and accurate.

8. **Interpersonal Skills:**

   Empathy: Understanding and considering the audience's perspective and potential concerns.

   Diplomacy: Addressing sensitive issues tactfully and respectfully.

9. **Technological Proficiency:**

   Word Processing Software: Proficiency in using word processing tools like Microsoft Word or Google Docs.

   Email Platforms: Understanding how to use email platforms if the circular letter is to be distributed electronically.

10. **Project Management:**

    Deadline Management: Ensuring the letter is written, reviewed, and distributed within the required timeframe.

    Collaboration: Working effectively with others if the letter requires input from multiple departments or individuals.

Applying These Skills

When writing a circular letter, here's how these skills come into play:

Planning: Use organizational skills to outline the key points you need to communicate.

Drafting: Employ clear communication and technical writing skills to draft the letter.

Reviewing: Apply attention to detail and proofreading skills to review the letter for errors.

Formatting: Use formatting skills to ensure the letter is easy to read and professional-looking.

Distributing: Leverage technological proficiency to distribute the letter through appropriate channels.

Tips for Writing Formal Circular Letters

- Omit needless detail. Tell the readers only what they need to know.
- Give just the important facts, not the whole background or history.
- Enclose or offer additional information for those readers who want detail, or refer them to a Website where more information can be found.
- When a program, event, or other thing is new, say so.

Technical writing skills for Mass Media

Articles are written on a scientific subject and are meant for communicating agriculture-related messages to a much wider audience, including poorly educated farmers and the general public. Since they are meant for the general public, they are relatively less technical in nature and are written in popular and vernacular languages. While communicating their research results through popular articles, the writers need to treat them in a different way as compared to scientific publications. They are generally published in popular magazines, periodicals, or newspapers that are widely circulated.

Importance

Popular articles are essentially prepared for the following purposes.

- Creating interest in a given subject among the readers.
- Providing accurate information about the subject.
- Persuading the readers to put into practice the recommendations.

Pre-requisites to conduct the skill

To write a captivating 'Article', the writer needs to adequately equipped with a minimum personal Desktop or Laptop computing system, wherein operating systems such as 'Microsoft Publisher' or even basic 'Microsoft Word' are the pre-requisite. Data visualization tools such as 'Microsoft Excel', 'R', 'Python' etc., and photographs/images with a minimum of 300 PPI—Pixels Per Inch in 'JPEG' or 'PNG' format are also indispensable.

Structure

While preparing an effective article, the message needs to be structured in such a way that it can create interest in the readers, convince them, as well as persuade them to put into practice what has been recommended. The structure includes the following critical elements.

Title: It is carefully selected to be short, catchy, exciting, and informative to draw the attention of the readers and create interest among them in the message being communicated.

Preamble: In this section, the importance of the topic and context of the article are indicated by the scientists to arouse the curiosity of readers.

Body: In this portion, the following heads are to be incorporated properly.

Organization: Instead of following any standard presentation structure, the intended message can be conveniently organized under short headings and sub-headings that are eye-catching and informative.

Visuals: The incorporation of visuals like photographs and figures can effectively complement the brief write-up under the headings and sub-headings.

Tables: Restrict the tables to a bare minimum that too with limited data in them.

Flow: Most importantly, the heading and sub-headings to be arranged in logical sequence to ensure smooth transition of information from one to the other.

Technical terms: As far as possible, use of terms that are too scientific/technical to be avoided. If their use becomes unavoidable, they need to be explained for the benefit fo readers.

Recommendations

Finally, the essence of the message needs to be summarized in the form of specific recommendations to enable the readers to easily comprehend and apply it in practice to reap the benefit.

Layout

Depending on the style followed by the periodical magazine or newspaper where the article is planned to be published, a short layout is to be followed.

Language

Being the most critical element of the whole write-up, a simple language that is easily understood by the target audience needs to be used by the writer.

Steps in writing

Writing an effective article requires the writers to follow the steps mentioned below in a sequential order.

Step 1: Assessing the information needs of the readers.

Step 2: Selecting the appropriate subject matter to meet the needs.

Step 3: Deciding on the purpose of writing to inform or educate or persuade.

Step 4: Prepare a broad outline.

Step 5: Compiling the needed information.

Step 6: Treat the collected information in a form most acceptable to the readers.

Step 7: Organizing the information in logical sequence under major headings and sub-headings.

Step 8: Preparing the first draft of the article.

Step 9: Revising and rewriting the article, if required.

Step 10: Publishing the article.

Tips for writing

The following tips may help the writers in writing effective popular articles.

- The readers' background and needs should be kept in mind while writing the article.
- A simple and easy to understand language should be used to effectively communicate the message.
- The message should be timely, up-to-date and able to meet the immediate needs of the readers.

Technical Skills for Preparation of Pamphlets

A pamphlet is an unbound book without a hard cover or binding. Pamphlets may consist of a single sheet of paper that is printed on both sides and folded in half, in thirds, or fourths, or it may consist of a few pages that are folded in half and saddle stapled at the crease to make a simple book. It may be a booklet usually containing 12 to 24 pages that deals with comprehensive information about either a topic or several related topics.

Advantages

i. Can reach a large section of literate people simultaneously

ii. They are valuable and effective materials for use in extension

iii. Can be preserved and used for reference purposes

iv. Comparatively cheap

v. Accurate information and minute details can be given

vi. Can be made easy as well as enjoyable to read

vii. Can promote literacy

viii. Improves authenticity of the information

Limitations

i. It is of little use in areas of low literacy

ii. Can't be used in exclusion of other methods

iii. Will lose its significance if not carefully prepared and used

iv. Owing to limited funds or facilities it is not possible to get them printed in large numbers

v. The distribution of pamphlets may sometimes be a very difficult task, as most of people would like to have a copy, even though they may not be of use to them

Importance of the skill and areas of application of the skill

Pamphlets educate readers and promote initiatives, events, and services. Pamphlets can contain information for educational, awareness, or marketing purposes and are considered an important tool for extension workers since they are cheap to produce and can be distributed easily. A pamphlet can increase public awareness, provide concise and valuable information, and reinforce the learning process. Its goal is to catch the attention of the audience and urge them to act. It takes a short time to read a pamphlet, thus it acts as a reminder of important points and it aims at changing knowledge and attitude or at teaching a behavioural skill. A properly designed pamphlet can communicate your message and leave a lasting mark on the reader.

Areas of Application: A mass contact method and can be used as a medium for sharing information and creating awareness among farmers and extension personnel.

Pre-requisites to conduct the skill

1. Computer (desktop, laptop) and its peripherals (including colour printer)
2. Printing material (paper)
3. Stapler and pins (for bound pamphlets)

Preparatory Activities (Planning) to conduct the Skill

- Define the purpose of your pamphlet (educational/awareness/marketing etc.)
- Consider your audience
- Decide on the topic and content of the pamphlet
- Gather relevant and detailed information on the topic
- Assemble pictures and images on the topic

Description of the Procedure to Conduct the Skill

1. Should be planned well in advance
2. Decide on a catchy and convincing headline

3. Plan the layout, appropriate caption and illustration have to be preplanned
4. Discuss the purpose, the message, the target audience and the content
5. While arranging the subject matter, there should be sequence in it
6. Keep the language simple by avoiding long and complicated sentences. The best pamphlets are short and simple.
7. All facts should be correct.
8. The readers should be facilitated to understand with pictures/illustrations
9. The concluding statement should summarize the key takeaways and motivate the reader to initiate action on his part.
10. Reviewing should be done for corrections
11. Incorporate the name of the organization published, serial number and discuss the quantity and quality of the pamphlet.

Diagram/ Images of the skill, activities etc.

Outcome/Information gathered etc.: Important tool for creating awareness, dissemination of information and as an aid in educational purposes

Skill Set (Agri. Extn) 5: Data Collection Using Seasonality Diagram

Introduction:

A seasonality diagram, also known as a seasonal calendar, seasonal activity profile, or seasonal analysis, is a widely used PRA (Participatory Rural Appraisal) method for conducting temporal analysis over annual cycles, using months or seasons as the primary units of analysis. This tool captures the local people's perceptions of seasonal variations across various aspects. While season diagrams do not rely on statistical data, they can be cross-verified with secondary or primary data to ensure the accuracy of the information collected.

Importance and areas of application of the seasonality diagram: The main strength of seasonal analysis lies in its ability to illustrate a variety of items and their magnitudes, which aids in understanding how these items are interconnected and influence each other. These relationships can provide significant insights.

Seasonal diagram helps to identify heavy workload periods, of relative ease, credit crunch, diseases, food security, wage availability etc.

- It has proved to be useful in project planning, i.e., when to implement various activities.
- It has been used to identify periods of stress and to plan for when intervention is most required.

- It is possible and analyses the livelihood patterns across the year.

Pre-requisites:

Seeds, cards, marker pens, chalk of different colours and other locally available materials like twigs, pebbles, etc., should suffice

Preparatory activities to conduct the seasonality diagram:

- Participants must be contacted well in advance
- The site or location to conduct the PRA exercise (seasonality diagram) must be chosen prior to the exercise
- A brief theoretical and good practical understanding of the exercise must be clear with the facilitator
- The time required for doing a seasonal diagram may vary depending on a host of factors, including the topic, interest of the participants, depth of information and analysis aimed at two to three hours. However, should be sufficient.
- While working with largely non-literate communities' symbols are most commonly used. But even with literate community's symbols are useful. Experience has shown that people are quick to find something unique with which to represent the month. Symbols or diagrams used commonly include:
  i)Fruits and crops unique to the month
  ii)Equipment, work, clothing, games, etc., unique to the month
  iii)Unique items or articles associated with the festivals falling during the month, etc.
  iv)Seasonal aspects, e.g., rain snow, sun etc.

Description of the Procedure for seasonality diagram:

The following suggested steps are recommended for making a seasonal diagram:

- Explain the objective of the exercise to the participants.
- Start a discussion on the present month and then the work they have been doing during the season. Move to the present month and then the other relevant ones. Write the names on cards in bold letters.
- Ask them to identify a unique characteristic of each month, one by one, that would remind them of the month. It can be a symbol or drawing. Encourage them to do it themselves. It can be fun and add to their involvement. This will ensure that even the non-literate participate meaningfully.
- Draw a grid with chalk on the floor. In the grid have a least 13 columns and many rows as the items you want to study. Keep the cards with names of the months and visuals or symbols in the top boxes in order, horizontally.
- Now on the vertical axis, take the aspects whose seasonal variations you are interested in to represent the magnitude of the activity using different number of seeds or sticks of different can be used to indicate the number of days. Similarly, sticks of different size can be used to indicate the quantity of rainfall during the month. After completing one aspect or activity move to another, until all of them are similarly covered.
- Ask the participants whether they would like to take up any other aspect or activity or make any modifications to the diagram. Interview the diagram, i.e., ask them questions on aspects about which you are not clear.
- Facilitate a discussion and analysis among the participants and others present. The points of discussion could include.
    - Major findings and learning

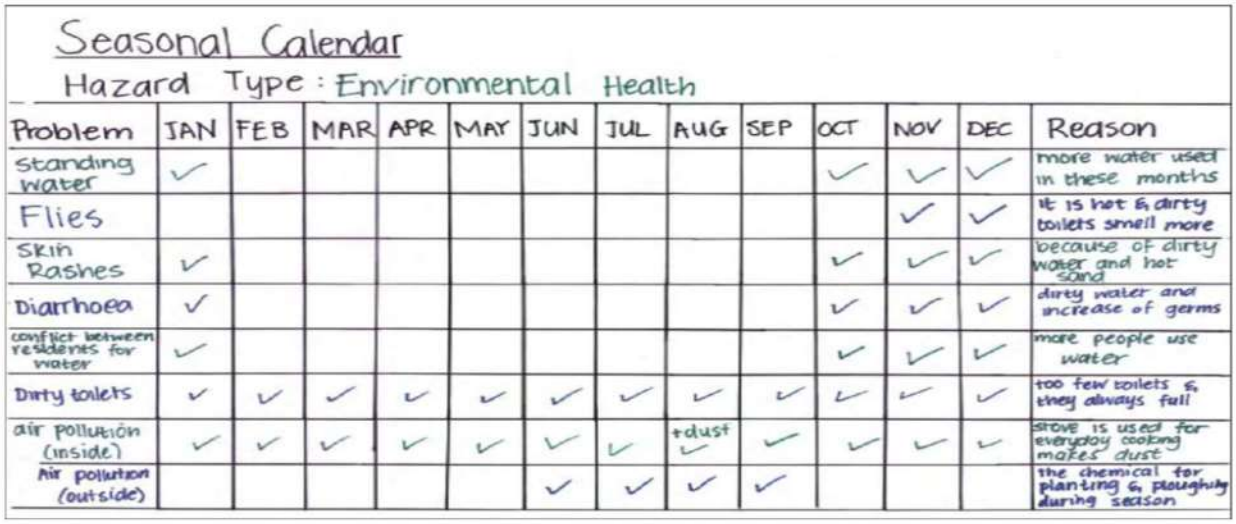
- Implication of the finding
- Recommendations and action points

- Please keep track of the points arising out of discussion among the participants right from the beginning. These provide equally valuable insights, if not more important ones, than the output itself.
- Copy the diagram on a piece of paper with legends and details of the participants, facilitators locality and date.
- Thank the participants for their active participation and valuable time.
- Later triangulate verify the findings with other key information to ensure that the information generated are correct.
- In some communities the concept of months may not exist at all. Similar questions with respect to the season may be quite revealing there.

Which month should be kept at the beginning of seasonal diagram?

The decision about the first month in the seasonal diagram should be left to the discussion of the people themselves. Whatever they are comfortable should be fine. In fact, that question need not be raised with the participants at all; just allow them to arrange and start from whichever month they are comfortable with. Experience shows that the rural and agricultural communities generally start the year from the month, which marks the beginning of a major agricultural season. You should develop a parallel between the two systems of time.

Diagram/Images of the seasonality diagram:



Seasonal Calendar

Hazard Type : Environmental Health

Problem	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Reason
standing water	✓									✓	✓	✓	more water used in these months
Flies											✓	✓	it is hot & dirty toilets smell more
Skin Rashes	✓									✓	✓	✓	because of dirty water and hot sand
Diarrhoea	✓									✓	✓	✓	dirty water and increase of germs
conflict between residents for water	✓									✓	✓	✓	more people use water
Dirty toilets	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	too few toilets & they always full
air pollution (inside)	✓	✓	✓	✓	✓	✓	✓	+dust ✓	✓	✓	✓	✓	stove is used for everyday cooking makes dust
Air pollution (outside)						✓	✓	✓	✓				the chemical for planting & ploughing during season

Outcome/Information gathered:

- It will show the seasonal patterns in rural areas related to rainfall, farming practices, employment etc. over the months in a year.
- Improvisation, creativity and flexibility are the hallmarks of PRA methods and seasonal diagram is no exception.

Skill Set (Agri. Extn) 6: Basic Skills in the documentation of data

What is documentation?

The process of systematically collecting, organizing, storing, retrieving, and disseminating information is called documentation. Output of documentation can be written, visual and audio information about an object, a practice, a product or an event. There are various types of documentation viz. annual reports, books, case study, digest, directories, guide, hand books, journal, manual, newsletter or bulletin, occasional papers, pamphlet, policy briefings, position paper, reports, training calendar, working papers, yearbooks, success story etc.

Why documentation is needed

- It aims to improve the quality and impact of a project.
- Enables to understand what is happening, how it is happening and why it may be happening
- To disseminate relevant knowledge and experiences in effective ways
- Foster innovation processes to scale and adapting them to other locations and contexts
- To monitor, evaluate and understand the impact
- To influence policies and practices
- To capture events, learning and experiences
- To generate knowledge and be an authority etc.

What to Document?

- Who, where, what, when
- Who all are involved, what exactly, when and where can you observe, why is it not happening, what is behind the surface, where the project life line makes the sharpest curves etc

How to Document?

- Observation of Meetings
- Personal interviews
- Focussed Group discussions
- Documentation of anecdotes and stories
- Diaries of project team members and/or stakeholders
- Photography and Video
- Disseminating channels
- Posters
- Newsletters
- Photographs Videos
- Blogs
- Summaries of meetings
- Success stories
- Case studies
- Radio/ TV programmes
- Websites

Elements of Documentation

- Clarity on the subject and overall objective (what/why)

- Complete understanding of the programme information (aim, time period, location, resources, actors, process, end results)
- Familiarity with various tools and techniques for generating information (FGD, Interviews, etc)
- Selection of appropriate medium (written, audio, video), format, style as per the context
- Good facilitation skills

How do we document

Major steps in Process Documentation are:

Step 1: Documentation prior to the start of any task: involves documenting the objective of the activity and approach; steps to be taken; why; who will be involved

Step 2: Documenting immediately following the Process task: what was actually done; modifications made on the approach and why; successes; what worked well; indicators used to gauge success; factors contributing to the success; actual achievements; progress; level of participation etc.

Step 3: Synthesis of findings and insights. Feedback may be obtained from stakeholders involved in the activities to find out factors which determined success; factors leading to failure; what worked well; what did not work well and needs to be adjusted; capacity building needed;

Step 4: Communication of findings and insights to stakeholders for obtaining feedback. Process Documentation is an invaluable tool in effective project management and governance. It aids action research, learning alliances and multi-stakeholder platforms that recognize the impact of cultural traditions and power constellations on development.

PLANT PROTECTION (ENTOMOLOGY)

Skill Set (ENT) 1: Insecticides and their formulation, pesticide appliances

Skills to impart: To learn different insecticides, formulation, and application

Classification of insecticide formulations

1. **Solid formulations**
   Dust, wettable or water-dispersible powder, granules, capsules, baits etc.
2. **Liquid formulations**

   The solution, emulsifiable concentrate, ultra-low volume formulations, suspension, etc.
3. **Gaseous formulations**
   Fumigants, aerosol, foams, smokes, mists and fog.

Different types of formulations

EC - Emulsifiable concentrate CG - Encapsulated granule CS - Capsule suspension DC - Dispersible concentrate DP - Dispersible powder EG - Emulsifiable granule EO - Emulsion, water in oil EW - Emulsion, oil in water ES - Emulsion for seed treatment FG- Fine granule SC- Suspension concentrate SE- Suspension emulsion SG- Water soluble granule SL- Soluble concentrate SP- Water soluble powder SS- Water soluble powder for seed treatment SU- Ultra-low volume suspension TB- Tablet	FS - Flowable concentrate for seed treatment G - Granule GC - Macro granule GL - Emulsifiable gel GP - Flo-dust GW - Water soluble gel OL - Oil miscible liquid OP -Oil dispersible powder WDP- Water dispersible powder WG- Water dispersible granules WP- Wettable powder WS- Water dispersible powder for slurry treatment WSC –Water soluble concentrate

PESTICIDE APPLICATION METHODS

The desired effect of a pesticide can be obtained only if it is applied by an appropriate method in appropriate time. The method of application depends on nature of pesticide, formulation, pests to be managed, site of application, availability of water etc.

1. Dusting: Dusting is carried out in the morning hours and during a very light air stream. It can be done manually or by using dusters. Sometimes dust can be applied to soil for the control of soil insects. Dusting is cheaper and suited for dry land crop pest control.

2. Spraying: Spraying is normally carried out by mixing EC (or) WP formulations in water. There are three types of spraying.

	Spray fluid (litre/acre)	Droplet size	Area coverage per day	Equipment used
a) High-volume spraying	200-400	150	2.5 ac	Knapsack, Rocker sprayers
b) Low volume spraying	40-60	70-150	5.6 ac	Power sprayer, Mist blower
c) Ultra-low volume spraying	2-4 lit.	20-70	20 ac	ULV sprayer, electronic sprayer

3. Granular application: Highly toxic pesticides are handled safely in the form of granules. Granules can be applied directly on the soil or in the plant parts. The methods of application are

a) **Broadcasting:** Granules are mixed with an equal quantity of sand and broadcasted directly on the soil or in a thin film of standing water.

b) **In-furrow application:** Granules are applied at the time of sowing in furrows in beds and covered with soil before irrigation.

c) **Side dressing:** After the establishment of the plants, the granules are applied a little away from the plant (10-15 cm) in a furrow.

d) **Spot application:** Granules are applied @ 5 cm away and 5 cm deep on the sides of the plant. This reduces the quantity of insecticide required.

e) **Ring application:** Granules are applied in a ring form around the trees.

f) **Root zone application:** Granules are encapsulated and placed in the root zone of the plant.

g) **Leaf whorl application:** Granules are applied by mixing them with an equal quantity of sand in the central whorl of crops like sorghum, maize, and sugarcane to control internal borders.

4. Seed pelleting/seed dressing: The insecticide mixed with seed before sowing

5. Seedling root dip: It is followed to control early-stage pests. Dipping of seedlings in pesticides before transplanting.

6. Sett treatment: Treat the sugarcane setts in 0.05% malathion for 15 minutes to protect them from scales. Treat the sugarcane sets in 0.05% Imidacloprid 70 WS @ 175 g/ha or 7 g/l dipped for 16 minutes to protect them from termites.

7. Trunk/stem injection: This method is used for the control of coconut pests like black headed caterpillar, mite etc. Drill a downward slanting hole of 1.25 cm diameter to a depth of 5 cm at a light of about 1.5 m above ground level and inject 5 ml of monocrotophos 36 WSC into the stem and plug the hole with cement (or) clay mixed with fungicide. Pseudo stem injection of banana, an injecting gun or hypodermic syringe is used for the control of banana aphid, vector of bunchy top disease.

8. Padding: Stem borers of mango, silk cotton and cashew can be controlled by this method. Bark of infested tree (5 x 5 cm) is removed on three sides leaving bottom as a flap. A small quantity of absorbent cotton is placed in the exposed area and pesticides is added using ink filler. Close the flap and cover with clay mixed with fungicide.

9. Swabbing: Coffee white borer is controlled by swabbing the trunk and branches with HCH (BHC) 1 per cent suspension.

10. Root feeding: Trunk injection in coconut results in the wounding of trees and root feeding is an alternate and safe chemical method to control black-headed caterpillar, eriophyid mite, and red palm weevils. Cut the end (slant cut at 45) of a growing root tip (dull white root) is placed inside the insecticide solution and the bag is tied with the root. The insecticide absorbed by the root, enters the plant system and controls the insect.

11. Soil drenching: Chemical is diluted with water and the solution is used to drench the soil to control certain subterranean pests.

1**2. Capsule placement:** The systemic poison could be applied in capsules to get a toxic effect for a long period. (e.g.) In bananas to control the bunchy top vector (aphid), the insecticide is filled in gelatin capsules and placed in the crown region.

13. Baiting: The toxicant is mixed with a bait material to attract the insects towards the toxicant.

a) Rats: Zinc phosphide is mixed at a 1:49 ratio with food like popped rice or maize cholam or coconut pieces (or) warfarin can be mixed at a 1:19 ratio with food. Ready-to-use cake formulation (Bromadiolone) is also available.

b) Coconut rhinoceros beetle: Castor rotten cake 5 kg is mixed with insecticide.

14. Fumigation: Fumigants are available in solid and liquid forms. They can be applied in the following way.

a) Soil: To control the nematode in soil, the liquid fumigants are injected by using an injecting gun.

b) Storage: Liquid fumigants like Ethylene dibromide (EDB), Methyl bromide (MB), carbon tetrachloride, etc., and solid fumigants like Aluminium phosphide are recommended in godowns to control stored product pest.

c) **Trunk**: Aluminium phosphide 7 to I tablet is inserted into the affected portion of the coconut tree and plugged with cement or mud for the control of red palm weevil

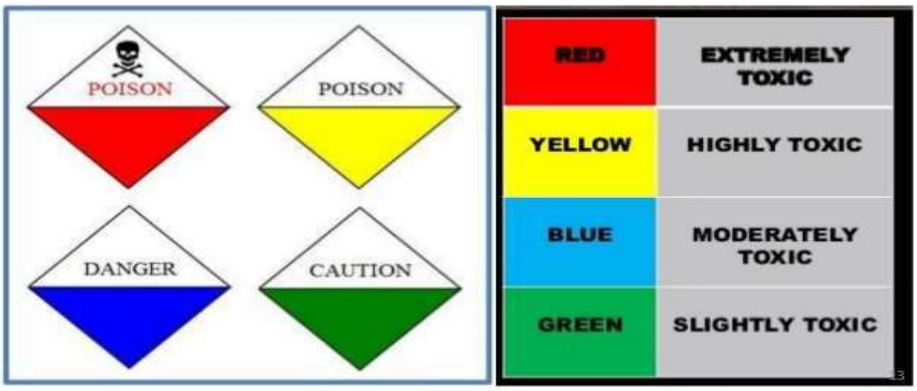
Skill Set (ENT) 2: Classification of insecticides based on LD_{50} values

Skills to impart : To learn different insecticides, formulation and application

The insecticides are classified into four groups on the basis of LD_{50} values

Sl.	Insecticides	Acute toxicity LD_{50} mg/kg	Dermal toxicity LD_{50} mg/kg	Colour of identification marked on the label
1	Extremely Toxic	1-50	1-200	Bright Red
2	Highly Toxic	51-500	201-2000	Bright Yellow
3	Moderately Toxic	501-5000	2001-20000	Bright Blue
4	Slightly Toxic	More than 5000	More than 20000	Bright Green

Handling of Pesticides



- Read the label carefully and follow the instructions given by the manufactures
- Keep the pesticides in labeled containers only
- Store pesticides under lock and key beyond the reach of children
- Do not store insecticides near foodstuff and store them in cool places
- Never use empty containers for any other purposes except for insecticides
- Destroy and dump the waste containers
- Wash hands with soap and water after using pesticides
- Do not use moths for cleaning nozzles etc. of sprayers.
- Avoid swallowing, inhalation, or contact with skin as far as possible.
- Keep the first air box ready along with the universal antidote.
- Activated charcoal 2 parts + tannic acid 1 part + magnesium oxide 1 part (Dose: 15 grams in half tumblers of water).
- Consult a doctor in case of signs of illness e.g. giddiness, nausea, headache, blurred vision, vomiting, depression, respiratory problem and inform about the pesticide the patient had handle.

The label of insecticides shall contain the symbol and warning statements. The label contains a diamond shaped square. The square shall be divided into two equal triangles, the upper portion shall contain the symbol and signal word as follows

1. Insecticide belongs to Category I (Extremely Toxic) shall contain the symbol of Skull and cross bones and the word “POISON” printed in red. The following warning statements shall also appear on the label at an appropriate place outside the triangle.

   “KEEP OUT OF THE REACH OF CHILDREN”

   “IF SWALLOWED OR IF SYMPTOMS OF POISONING OCCUR, CALL PHYSICIAN IMMEDIATELY”

2. Insecticide in category II (Highly toxic) will contain the word POISON printed in red and the statement KEEP OUT OF THE REACH OF CHILDREN shall also appear on the label a appropriate place outside the triangle.
3. Insecticide in category III (Moderately Toxic) shall bear the word "DANGER" and the statement "KEEP OUT OF THE REACH OF CHILDREN" shall also appear on the label at suitable place outside the triangle.
4. Insecticides in Category IV (Slightly toxic) shall bear the word "CAUTION"

Skill Set (ENT) 3 : Identification of major insect pest of medicinal and aromatic crops

Skills to impart : To learn characteristics of insect pest of medicinal and aromatic crops

Sl. No.	Systemic position	Marks of identification	Nature and symptoms of damage
Insect pests of opium			
1.	Cutworm *Agrotis ipsilon* (Lepidoptera: Noctuidae)	 Adult moth is brown in colour with some greyish patches on the fore wings. Full grown larva is dark brown in colour.	The larval stage is the most damaging. Young larvae feed on the epidermis of the leaves, but the older larvae cut the stems of the plants either below the surface or above the ground.
2.	Aphid, *Myzus percisae* (Hemiptera: Aphididae)	 Adults as well as nymphs are yellowish green in colour with a pair of cornicles on the abdomen.	Both adults and nymphs suck the cell sap. Secrets honeydew-like secretion which develops sooty mold. The attacked leaves turn yellow in colour and plants give a sick appearance.
3.	Capsule borer, *Helicoverpa armigera* (Lepidoptera: Noctuidae)	 Adult moth is stoutly built;	Larval stage is the damaging stage. Initial instar feed on the foliage and later bore into the head and feed on the developing capsule, with their bodies hanging outside.

		medium size; brown with 'V' shaped speck and dull black border on the hindwing. Full grown caterpillars are greenish with dark broken grey lines along the sides of the body.	
Insect pests of senna			
1.	Green leaf eating caterpillar, *Catopsilia pyranthi* (Lepidoptera: Pieridae)	The adult butterfly is white in colour; a black tip is present on male forewing and black margin around each wing and brown speckles in females. Larva is green in colour with yellow colour bands	Larvae feed on young and tender leaves.
2.	Pod borer, *Etiella zinckenella* (Lepidoptera: Pyralidae)	 Adults are medium-sized moths with forewings having dark marginal lines. Larvae are greenish at the early stage, full-grown larvae are rosy with a purplish tinge.	The larval stage is the damaging stage. Tiny greenish caterpillars enter the pods and eat away the young grains. Minute holes are visible on the pods.

Insect pests of neem			
1.	Tea mosquito bug, *Helopeltis antonii*, *H. theivora* (Hemiptera: Miridae)	The adult is a black colour slender insect, with a red thorax, black and white abdomen, and greenish-brown wings; female bug is orange across the shoulders and the male is almost black. A thoracic knob that is reddish brown, erect, and tapering with the tip knobbed and funnel-shaped	Nymphs and adults suck the sap from plant tissues giving a burnt appearance to the affected branches. Tip drying of the leaves
2.	*Megapilminaria maxima* (Coccidae: Hemiptera)	 Minute scale insect settle near the leaf veins soon after emergence from egg.	The nymph suck the sap leading to complete drying of plants.
Insect pests of *Dioscorea* sp. (Greater Yam/Asiatic Yam)			
1.	Aphids, *Aphis gossypii,* (Hemiptera : Aphididae)	 Adults are small, soft and brown to black.	Both nymph and adults suck the sap from leaves and stems of young vines.
2.	Red spider mite, *Tetranychus sp.* (Tetranychidae: Acarina)	 Adult is light brown in colour with two eye-spots and four pairs of legs.	Both adult and nymphs cause damage by sucking cell sap on the underside of the leaves.
Insect pests of *Crotalaria*			
2.	Sunnhemp Hairy Caterpillar, *Utetheisa pulchella* (Lepidoptera : Arctiidae)	The adult moth is pale, whitish with red black spots on the upper wings and black marginal blotches on the lower wings.	Caterpillar is the damaging stage. Caterpillars defoliate as well as feed on the pods by thrusting the head in.

		Larva is a hairy caterpillar having reddish-orange and white bands on the body with dark spots.	
Insect pests of Belladona			
1.	Cutworm, *Dichagyris flammatra* (Lepidoptera: Noctuidae)	 Adult moth brownish in colour; forewings with black patches and a black collar which is the identifying mark.	Larva attacks the tender seedlings during early summer months. Seedlings and young plants are cut at the ground level.
2.	Leaf feeder, *Archips micaceana* (Lepidoptera: Tortricidae)	 Adult moths are brown in colour with greyish patterns on forewings, females possess a tuft of hairs on the last abdominal segment	Caterpillars feed on the leaves
Insect pests of mint			
1.	Cutworm, *Agrotis* spp., *Spodoptera exigua* (Lepidoptera: Noctuidae)	*Agrotis* – same as in opium *Spodoptera exigua*- Forewings of adult moths are mottled grey and brown with an irregular banding pattern and a light-coloured bean-shaped spot. Initial larval instars are pale green, but the later in stars are darker in colour with a dark lateral stripe.	The larvae feed on all portions of the plant but are usually found under the canopy rather than on the top of the plants. It is not uncommon, however, to find larvae feeding on the terminal buds
2.	Aphid, *Myzus persicae* (Hemiptera: Aphididae)	Same as in opium	Both adults and nymphs suck the cell sap. Sooty mold develops due to honey dew secretion which hinders in photosynthesis.

Insect pests of *Solanum nigrum* Black nightshade			
1.	Mealybugs, *Paracoccus marginatus* and *Phenacoccus solenopsis* (Pseudococcidae: Hemiptera)	Adult female mealybug is wingless with a flattened body having short, waxy filaments along the margin; males are fragile winged insects. 	In case of severe infestations, clusters of mealybugs could be seen on the lower surface of the leaves giving an appearance of thick mat with waxy secretions. Leaves become yellow and finally wither as well as sooty mold growth can be seen.
2.	Aphids, *Aphis craccivora* (Aphididae: Hemiptera)	Adults as well as nymphs are minute, delicate, pear-shaped, dark brown winged or wingless insects with a pair of minute tubular structures called cornicles. 	Both nymphs and adults occur in colonies on lower surface of leaves and terminal shoots. They suck the sap resulting in curling and crinkling of leaves. Honeydew excretion and sooty mould are the typical symptoms of damage.
3.	Thrips, *Thrips tabaci* (Thripidae: Thysanoptera)	 Adults are slender, yellowish brown; females have long, narrow strap-like wings which are furnished with long hair along the margins.	Nymphs and adults lacerate the leaves and suck the sap causing upward curling of leaves.
4.	White Flies, *Bemisia tabaci* (Aleyrodidae: Hemiptera)	 Adults are minute-winged insectsbodiesh yellow body and white wings, covered with	Nymphs and adults suck the sap causing chlorotic spots on the leaves which later coalesce to form irregular yellow patches on the leaves which may dry and fall.

		white waxy materials. Nymphs are oval and greenish yellow in colour.	
6.	Hadda Beetle, *Henosepilachna vigintioctopunctata* (Coccinellidae: Coleoptera)	 Adult beetles have a convex body, deep red in colour with 28 black spots on the elytra. Grubs are oval, fleshy and yellow in colour bearing hairs and spines on the body.	Grubs and adult beetles scrap the chlorophyll of the leaves in between veins resulting in skeletonized patches which could be seen on the upper surface of leaves giving lace-like appearance.

Skill Set (ENT) 4 : Identification of pesticide appliances

Skills to impart : To learn and identify different types of pesticide applicators

Pesticide application plays an important role in pest management. The proper technique of application of pesticide and the equipment used for applying pesticide are vital to the success of pest control operations. The main purpose of pesticide application technique is to cover the target with maximum efficiency and minimum efforts to keep the pest under control as well as minimum contamination of non-targets. The application techniques ideally should be target oriented so that safety to the non-targets organisms and the environment is ensured. Therefore, proper selection of application equipment, knowledge of pest behaviour and skillful dispersal methods are vital. The complete knowledge of pest problem is important to define the target i.e., location of the pest (on foliage, under the leaves, at root zone etc.). The most susceptible stage of the pest for control measures will help to decide the time of application. The requirement of coverage and spray droplet size depends upon the mobility and size of the pest. Further, the complete knowledge of the equipment is necessary to develop desired skill of operation, to select and to estimate the number and type of equipments needed to treat the crop in minimum time and to optimize use of the equipment.

Classification of plant protection equipment

Sprayers

- The Sprayer is one which atomizes the spray fluid (which may be a suspension, an emulsion or a solution) small droplets and eject it with little force for distributing it properly.
- It also regulates the amount of pesticide to avoid excessive application that might prove wasteful or harmful.
- The mechanical appliances that are used for distributing the dust formulations of pesticides are called dusters.

Types of sprayers

Sprayers are classified into four categories on the basis of energy employed to atomize and eject the spray fluid as

- Hydraulic energy sprayer
- gaseous energy sprayer
- centrifugal energy sprayer and,
- kinetic energy sprayer

Hydraulic energy sprayer

- Hydraulic Energy Sprayer is one in which the spray fluid is pressurized either directly by using a positive displacement pump or by using an air pump to build the air pressure above the spairtight in the air tight container.
- The pressurized fluid is then forced through the spray lance, which controls the spray quantity and pattern.

Gaseous energy sprayer

- In Gaseous Energy Sprayer high velocity air stream is generated by a blower and directed through a pipe at the end of which the spray fluid will be allowed to trickle by the action of gravity through a diffuser plate.

Centrifugal energy sprayer

- In the Centrifugal Energy Sprayer, the spray fluid fed under low pressure at the centre of a high speed rotating device (Such as flat, concave or convex disc a wire mesh cage or bucket, a perforate sieve or cylinder or a brush) is atomized by centrifugal force as it leaves the periphery of the atomizer.
- The droplets are carried by the air stream generated by the blower of the sprayer or by the prevailing wind, if the sprayer is not provided with a fan.

Kinetic energy sprayer

- In Kinetic Energy Sprayer the spray fluid flows by gravity to a vibrating or oscillating nozzle which produces a coarse fan shaped spray pattern.
- This is used for application of herbicides.

Types of sprayers

- Depending on the source of power it can be classified as manually operated and power operated dusters.
- The manually operated dusters are (i) package duster (ii) plunger duster (iii) bellow duster and (iv) rotary duster.

Uses of spraying and dusting equipment

- The spraying and dusting equipment are used for the following purposes
- For the insecticides application to control insect pests on crops and in stores, houses, kitchen, poultry farms, barns, etc.
- For the insecticides application to control insect pests on crops and in stores, houses, kitchens, poultry farms, barns, etc.

- For the acarices application to control phytophagous mites.
- For the fungicides and bactericides application to control the plant diseases.
- For the herbicide's application, to kill the weeds.
- For the harmone sprays application to increase the fruit set or to prevent the premature dropping of fruits.
- For the application of plant nutrients as foliar spray.
- For applying the powdery formulation of poisonous chemicals on the crops and for any other purposes.

Hand sprayer

- The hand sprayer is a small, light, and compact unit.
- The capacity of the container varies from 500 to 1000 ml.
- This is generally used for spraying small areas like kitchen gardens and experimental laboratory plots.
- It is a hydraulic energy sprayer.
- It has a hydraulic pump inside the container, with a cylinder, plunger, and a plunger rod.
- By operating the plunger up, the spray fluid in the container is sucked into the cylinder through a ball valve assembly and then pressurized during the downward stroke.
- The pressurized fluid is then let ounozzle and nozzle, and sprayed into fine droplets.
- If the pressure is to be built inside the container an air pump with cylinder, plunge, and plunger rod is required.
- When the plunger is pulled up, the air is sucked into the cylinder and when pushed down the air bubble is released into the container with 80% of its volume filled with the fluid.
- The air reaches the space above the free fluid surface and presses the fluid.
- The pressurized fluid is drawn up through a trigger cut of the valve to the nozzle, where is atomized and sprayed.
- In some other types, the air pump and the container are separate pieces, and the pump is attached to the container in such a way as to release the pressurized air through an orifice at the top of the container.
- The fluid is lifted through an office at the top of the container.
- The fluid is lifted through a capillary tube due to surface tension developed by the high-velocity air at the outlet and sheared away by the air and sprayed as droplets.

Knapsack sprayer

- Any sprayer which is carried on the back of the operator is called a knapsack sprayer.
- The commonly used manually operated knapsack sprayer will have one hydraulic pump working inside the container.
- The plunger works inside the replacement well attached at the bottom of the container, for easier maintenance.

- The pump can be operated through the appropriate linkages by oscillating the handle, with the sprayer carried on the back.
- An agitator is also provided with the pressure chamber to agitate the fluid so that the particles in suspension will not be allowed to settle down.
- A delivery tube is attached to the other end of the pump which carries the pressurized fluid to the spray lance.
- The flow to the nozzle is controlled by a trigger cut-off valve.
- In the case of a compression knapsack sprayer, an air pump is used to build air pressure above the free surface of the spray fluid in the container, and normally the pumping of the air will be done by keeping the unit on the ground and then sprayed till the air pressure comes down.
- The unit is again brought back to the ground for pumping air and then the spraying is contained as before.
- The spray fluid, which does not require any agitation only can be sprayed by using this type of sprayer.

Rocker sprayer

- The rocking sprayer has a pump assembly, fixed on a wooden platform with an operating lever, a valve assembly with two ball valves, a pressure chamber, a suction hose with a strainer, and a delivery hose with a spray lance.
- When the plunger is pulled behind by pulling the lever away from the pump, the spray fluid from the container is sucked through the strainer and pushes the bottom ball valve above and enters the pump.
- The movement of the lower ball valve is arrested by the upper valve seat.
- When the lever is pushed towards the pump, the sucked fluid is forced to enter the pressure chamber by opening the upper ball valve
- The operation is continued till the entire suction pipe, ball valve assembly, delivery hose, and a portion of the pressure vessel are fitted with spray fluid and the pump operator finds it difficult to push the piston forward, due to the downward pressure developed by the entrapped compressed air in the pressure vessel.
- Thereafter, the trigger cut-off valve will be opened to allow the spray fluid to rush through the nozzle and get atomized.
- Usually 14 to 18 kg/cm2 pressure can be built in the pressure chamber and hence can be conveniently used for free spraying.

Bucket sprayer

- The bucket sprayer is designed to pump the spray fluid directly from the open container, usually a bucket.
- The hydraulic pump will be put inside the bucket and held properly with the hefootrestt rest.
- As the plunger is pulled up, the fluid enters through the suction ball valve assembly and when the plunger is pressed down, the suction valve closes, and the fluid enters the pressure chamber through a ball valve assembly.

- As the plunger is continuously worked, pressure is built in the pressure chamber and the delivery hose.
- As soon as the required pressure is built up, the spraying will be done.
- A pressure of 4 kg /cm^2 is developed in most of the models.

Foot sprayer

- This is a modified version of a rocker sprayer.
- The pump is fixed in a vertical position with necessary braces.
- The plunger moves up and down when operated by the pedal.
- A ball valve is provided in the plunger assembly itself to allow the fluid to cross the plunger and get pressurized in the pressure vessel.
- During the upward motion of the piston fluid is sucked in and pressurized into the pressure vessel and during downward movement, the sucked fluid crosses the plungers and enters the pump.
- The pressure developed is about 17-21 kg/cm^2.

Power sprayer

- All the sprayers which impart the mechanical energy developed by an I.C. Engine, on the spray fluid before spraying is called a power sprayer.
- The most used type of power sprayer in India is a gaseous energy type knapsack sprayer.
- In construction, it has a backpack stand on which a blower with a S.I.
- Engine of 1.2 to 3 hp capacity, the spray fluid tank and the petrol tank are fixed rigidly.
- A pleated hose is attached to the blower elbow to carry the high velocity air and at the end of that a shear nozzle is fixed to allow the spray fluid to trickle in from the spray fluid storage tank, with a valve control
- From the top of the blower casing, an air hose is taken into the spray fluid tank, which carries little quantum of air to press the spray fluid during operation.
- In operation, the engine is started by keeping the unit on the ground and then carried by the operator.
- The blower sucks the air behind the backrest and forces it into the pleated hose.
- The valve of the shear nozzle is opened or the shear nozzle with selective opening and discharged through the nozzle.
- The high velocity air shears off the droplets and atomizes by the impact of diffuse and delivers it on the plant surface.
- An air current of 2.7 to 9.1 m^2 / minute is delivered at a velocity of 175 to 320 kmph.
- The spray fluid tank capacity varies from 7 to 12 litres.
- The fuel tank capacity varies from 0.75 to 2.25 litres.
- The spray fluid discharge can be varied from 0.5 to 5 lit / minute.

A power sprayer can be used as a power duster by making the following changes.

- A chemical filler cap is removed to dismantle that strainer with the air pipe.
- The liquid delivery pipe below the chemical tank is dismantled and removed with the shear nozzle.
- The tank is thoroughly cleaned to remove possible traces of moisture left inside.
- The dust agitator tube is fixed at the bottom of the chemical tank.
- This tube has holes at the bottom to prevent the entry of dust into the agitator and clogging it.
- Dust intake tube is inserted into the chemical tank at the discharge and this tube has no. of large size holes on its periphery.
- Dust intake tube and the blower elbow are connected by using the dust outlet pipe, which is a pleated hose.

Battery or ULV sprayer

- ULV sprayer was invented as a result of the desire to reduce the quantum of chemical carried by the man for application and to eliminate the water as a medium to carry the chemicals.

Dusters

(i) Package dusters

- In some pesticide dusts are packed in containers that serve as a hand applicator and may be discard after use.
- They are mostly provided with rubber, leather or plastic sections which, on getting squeezed, provides a puff of air that emits the dust in a small cloud.
- The simplest type of package duster works by pressing it between the fingers.

(ii) Plunger dusters

- The consists of an air pump of the simple plunger type, a dust chamber, and a discharge assembly consisting of a straight tube or a small exit pipe whose discharge outlet can be increased or decreased by moving a lid provided at the end of the dust chamber.
- The air from the pump is directed through a tube into the container where it agitates the dust and ejects it from a discharge orifice or tube.
- The amount of dust can be controlled by the speed of the operation of the pump.
- These are useful for spot application in restricted areas and for controlling ants, poultry pests, and pests of farm animals.

(iii) Bellow duster

- In the below may be made from rubber, leather or plastic.
- On squeezing, it puffs the air that expels the dust in a small cloud.
- Handheld bbelowduster has containers of capacity from 30 g to 500 g.
- The bellows can be operated either directly by hand or by handle provided for that purpose.
- The knapsack duster has a container capacity of 2.5 to 5.0 kg.

- The air blast developed by the below draws the dust from the hopper and discharges through the delivery spout intermittently.
- These dusters are suitable for spot treatments.

(iv) Rotary duster

- A consists basically of a blower complete with a gear box and a hopper. It is operated by rotating the crank.
- The cranking motion is transmitted through the gear box to the blower.
- A drive is taken for the dust agitator located in the hopper.
- The rotary duster may be hand carried type or shoulder mounted or belly carried type.
- The feed is controlled by a feed control lever, which operates a slide to control the aperture at the bottom of the hopper.

(v) Power dusters

- This resemble the rotary duster is construction, except that the power to drive the blower through the gear box is tapped from an external power source which may be an engine or P.T.O. shaft of the tractor or flywheel of the power tiller.

Skill Set (ENT) 5 : Identification of birds and bird control

Skills to impart : To learn different birds and control measures

India is bestowed with rich avi-faunal diversity and the number of bird species recorded in the country is more than 1200 belonging to 20 avian orders. Many of the birds are important pollinators and indicators of a healthy ecosystem. Since ancient times, birds have been an essential component of attractiveness, and many cultures have an amazing place in their mythology for birds. Most of these birds have a complex status (beneficial/depredatory/neutral/unknown) about their habitat. Out of 63 species of birds belonging to 19 families have been identified to damage several crops and among the 46 species of beneficial birds, which devoured insects and rodent pests, all fed on insects while six of them also consumed rodents. The extent of crop damage caused by birds depends on of several factors, including the concentration of the local bird population, the total area covered with crops, cropping pattern, season, and the physiological status of birds. Managing depredatory birds is considerably different from the conventional pest management approaches. Indian Wildlife (Protection) Act, 1972 prohibits the use of any measures to trap harm, or kill most of the bird species, let alone the national or endangered or threatened species.

Economic Importance

Crops are being damaged by birds at the sowing, ripening, and harvesting stages. After crop harvest, bird damage continues at grain stores, shelling yards, and marketplaces. At the sprouting stage-sometimes this damage is so severe that farmers sow to re-sow the affected fields. The re-sowed crop may mature later than those sown at the normal time and suffer related more bird damage at the ripening stage. When birds have eaten seeds or pulled out seedlings they are taken away from the field. Fruits injured by birds lose marketability. Thus, one attack of a bird on a seed or a fruit produces a 100% loss it. Cereals are more vulnerable to bird attack especially at the dough stage. Damage to the crops of smaller grains such as pearl millet and sorghum was more serious as compared to that in large size grains Small cereal grains were preferred by both smaller and larger birds, whereas maize was

depredated primarily by larger species such as parakeets and crows. Isolated fields are always prone to bird damage; early and late maturing fields are highly susceptible. Hence or the even distribution of bird damage, synchronization of crop cultivation is advocated.

Bird damage to major crops and fruits

Crop/Fruit	Stage of damage	Bird	Extent of loss (%)
Groundnut	Ripening	Crows	24
Maize	Sprouting	Crows, Doves, Babblers	20
Mustard	Ripening	Parakeets, Crows	63
Pearl millets	Ripening	Sparrows, Parakeets, Weaverbirds	10-100
Peas	Ripening	Pigeons	54
Pulses	Sprouting	Doves, Pigeons, Parakeets, Sparrows	66
Rice	Sprouting	Weaverbirds, Sparrows	41
	Ripening	Sparrows, Weaverbirds, Munias, Parakeets, Saras cranes	26
Sorghum	Ripening	Pigeons, Doves	12-85
Sunflower	Sprouting	Crows	65
	Ripening	Crows , parakeets	22
Wheat	Sprouting	Crows	17-20

Identification of important bird pest

Rose-ringed parakeet (*Psittacula krameri*) Habits: A very adaptable species often associated with cultivation. Causes severe damage to Maize, Pearl millet, Wheat, Paddy, Sorghum, Sunflower, Safflower

Rosy pastor (Sturnus *roseus*) Habit:- Gregarious, form huge flocks at rich feeding sources. Causes damage to pearl millet, sorghum

House sparrow (*Passer domesticus*) • Causes damage to pearl millet, paddy, sunflower. It also feeds on green leafy vegetables.

House Crow (*Corvus splendens*) • Habitat: Closely associated with human activity. It causes damage in wheat, cobs of maize, jowar, groundnut, ripe fruits of fig, mulberry, and chilies.

Baya Weaver (*Ploceus philippinus*) • Habitat: Cultivation, Paddy fields. It causes damage in rice, pearl millet, wheat

Eurasian Collared Dove (*Streptopelia decaocto*) Habits: Often congregates in flocks where food is abundant. It damages the wheat fields

Blue Rock Pigeon (*Columba livia*) •Habits: Lives in colonies all year. It feeds on cereals, pulses, nuts

Ruff and Reeve (*Philomachus pugnax*) It causes damage in the wheat fields. Damage by these birds was reported first time in coastal areas of Gujarat when the crop was at the sowing and seedling stage.

Black-tailed Godwit (*Limosa limosa*) •Habits: Feeds mainly by walking slowly. It causes damage in the wheat fields at the sowing and seedling stage.

Lesser Whistling Teal (*Dendrocygna javanica*) •Habits: Roosts in the daytime in trees •Habitat: grass land and paddy fields. It causes damage in paddy crops

Demoiselle Crane (*Anthropoides virgo*) • Habits: Highly Gregarious. It causes damage in Wheat and Groundnut crops. The migratory Demoiselle cranes can cause damage up to 10% at the time of harvesting of groundnut crop.

Short – toed lark (*Calandrella cinerea*) • Habit: Similar to those of other larks. it was reported that it caused damage in wheat fields heavily in Bhal area of Gujarat.

Pied Myna or Asian pied starling • Granivorous bird feeds mainly on sorghum

Bird Pest control

The various methods that can be adopted by the farmers to minimize the damage caused by depredatory birds are given hereunder without impeding the impacted aims.

1. Indigenous Machan Flagged Bamboos Scarecrow on the Machan

2. Artificial predatory birds Covering polythene sheets Throwing stones Hanging birds

3. Integrated Bird Pest Management (IBPM) using reflective ribbons and botanicals in sorghum and wrapping in maize along with ribbon fields. During the vulnerable stage of the maize crop wrapping of cobs along with the installation of reflective

4. Habitat manipulation: Creating continuous disturbances to the nesting sites of the depredatory breeding birds in around the cropped areas that the birds will force to leave breeding grounds and shift to another area. Example, for parakeets in additional to manual destruction of nests, closing the entrance of the nests proved effective in reducing their populations.

5. Planting of some fruit-bearing trees as attractants like Manila tamarind (*Pithecalobium dulce*), Flame of the forest (*Butea monosperma*) Mulberry (*Morus alba*), and Toothbrush tree (*Salvadora persica*) in and around cropped area attracts many granivorous birds during fruiting period and reduces the impact at vulnerable stage of the crop

6. Netting is the best method and gives complete protection to the crops. The nylon net has a mesh that sufficiently prevents the passage of even small granivorous birds. The method is recommended for

high-value trails (or) breeder seed experiments or multiplication trails. It is very expensive for large acreage plots.

7. Camouflage: a method involving camouflaging maize cobs has been discovered that protects ripening maize from rose-ringed parakeets (Dhindsa et al 1990).

8. Wrapping method on maize crop: Covering maize cobs by wrapping adjacent green leaves around them reduced the damage to a negligible level by parakeets and crows. Being hidden and camouflaged, the wrapped cobs escape detection by birds. Parakeet damage is restricted to peripheral rows, covering 50% of cobs at random on the outer rows of the field is sufficient to effectively reduce bird damage. This method is very simple and effective.

9. Reflective ribbon is a polyester film with a metallic shining coating with red on one side and silver on the other. It is prepared by cutting along a continuous polyester sheet in to strips of 1.5 cm width. Strips preferably 15 to 20 cm long, are fixed parallel to the crop at 0.5 m height above the crop and at 5m intervals using bamboo poles and strings.

   For better reflection the string should be placed in North to south direction. During sunshine the reflection of sunlight and humming noise produced by the wind scares the birds from the field. This device is effective only for 15 to 20 days. This technique is very effective and easily acceptable to the farmers. Birds like rose ringed parakeet, house sparrow, house crow and mynas on the crops like sunflower, maize, sorghum, pearl millet, and orchards are scared by this device. Effective against Demoiselle cranes in groundnut and against depredatory birds in other cereals and fruit crops.

10. Bioacoustics: The acoustic equipment consists of 1 stereo tape recorder with 30 w amplifier, 2 speakers and one 12 v battery. Distress calls of birds were pre-recorded in tape. The operation of the equipment should be done from about 100 meters and the speakers should kept in a bushy spot near the field area. Depending on the intensity of bird activity, the frequency of play should be set at regular time intervals. Broadcasting of such distress calls of depredatory birds kept the birds away from Maize fields and also other crops. This method is very effective on orchards and small acreage crops.

11. Botanical repellent: Neem cake solution is prepared by soaking neem cake @ 200 or 300 g/lit. of water and kept for fermentation for 8-10 days. The fermented solution is then decanted and this solution is used as spray fluid. Neem cake solution @200 g/lit of water showed effective in controlling bird damage in maize.

Skill Set (ENT) 6 : Honeybee species and castes of bee species

Skills to impart : To identify and learn different honeybee species and castes of bee species

Beekeeping or apiculture is the maintenance of honeybee colonies under the genus *Apis*, commonly in man-made hives, by humans for honey, beeswax, propolis, flower pollen, royal jelly, bee venom, to pollinate crops and to produce bees for sale to other beekeepers. Another group of honeybees known as Dammer bees or Stingless bees belong to the family Apidae and the tribe Meliponini also yield honey but less than the honeybees however, their honey is considered to be superior and much costlier than the normal honey. The rearing and maintenance of stingless bees in the artificial hive is known as Meliponiculture.

In India, there are 4 species of honeybees under genus *Apis* and 2 groups of stingless bee under the genus *Tetragonula* and *Lepidotrigona* which are commonly found foraging under natural conditions. They are:

1. (Rock bee/Giant bee) *Apis dorsata*

- They are the largest of all bee species.
- Construct a single comb in the rock cliff, trees, ceiling, etc. and love opened environment.
- Sometimes the comb measures 1.5-2 m across diameter.
- They are migratory in nature.
- Wild and ferocious in nature therefore cannot be domesticated.
- The colony can store 40-50 kg of honey per year.
- Foraging range is more than 2km.

2. (Little bee/dwarf bee) *Apis florea*

- They are the smallest of all bee species.
- Construct single comb in shrubs and trees etc. and also love open environment.
- They are also migratory in nature.
- Wild in nature therefore cannot be domesticated.
- The colony can store 250g of honey per year.
- The foraging range is short which usually does not extend *500 m.*

3. (Indigenous/Indian bee) *Apis cerana*

- They are smaller than *Apis dorsata* but larger than the *Apis florae.*
- Workers are black in colour, with four yellow abdominal stripes.
- Construct multiple combs side by side and parallel to each other inside hollow tree trunk, walls, unused box etc. and required closed environment.
- Mild in temperament and therefore can be domesticated.
- They have swarming and absconding behaviour.
- The colony can store 12-15 kg of honey per year.
- Foraging range is 0.8-1 km

4. (European/ Exotic bee) *Apis mellifera*

- They are larger than *A. cerana* but smaller than *A. dorsata*
- They also construct multiple combs side by side and parallel to each other and love closed environments.
- Mild in temperament and therefore can be domesticated.
- Swarming and absconding behaviour is less compared to *A. cerana*.
- The colony is usually larger than *A. cerana* and can store 25-40 kg of honey per year.
- Foraging range is up to 2km

5. (**Stingless bee**) *Tetragonula* sp. and *Lepidotrigona* sp.

- They are very small (body length range from 2.95-4.70 mm)
- The body is brown to black with reduced wings venation.
- They have stingers, but they are highly reduced and cannot be used for defence.
- Stingless bees also love closed environment, usually nest in hollow trunks, underground cavities, rock crevices and in wall cavities.
- They don't have definite structures of comb. However, the bees store pollen and honey in large, egg-shaped pots made of "cerumen". These pots are often arranged around a central set of horizontal brood combs, wherein the larvae are housed.


Worker of *Apis dorsata* with their feral hive


Worker of *Apis florae* with their feral hive


Worker of *Apis cerana* with their feral hive


Worker of *Apis mellifera* with their feral hive


Worker of *Tetragonula* sp. with their feral hive


Worker of *Lepidotrigona* sp. with their feral hive

Organization of honeybee colony

Both honeybees and stingless bees are social insects and live in colonies with a highly organized system of division of labour. They have 3 castes, the Queen, the Workers and the Drones

Queen: She is the mother of the colony and is responsible for laying eggs. Her reproductive organs are well-developed and have a large abdomen generally two or three times bigger than a worker's. She can be distinguished by her extended abdomen and provided with a combined sting and ovipositor. *Apis cerana* queen can lay 500-600 eggs/day whereas; *A. mellifera* queen can lay 1000-1500 eggs/day and the stingless bee queen can lay only a few hundred less than the other two. The queen can lay both fertilized and unfertilized eggs. From fertilized eggs queen and worker are developed and from unfertilized eggs, only the drone will develop. The queen does not have a pollen basket, does not feed her own do does not collect pollens and also do not produce honey. Her only function is to lay eggs. In one colony, there will be only one queen however, in some species of stingless bee; there may be more than one queen in a colony and queen lives for 2-5 years and when it is weak or unable to lay eggs, it is replaced by one of the daughter queens.

Worker: They are responsible for every work both inside and outside the beehive. They are also sometimes called the driving force of the colony. In a strong colony of *A. cerana* there may be around 60,000 to 100,000 worker bees and about 50-10,000 workers bee in case of stingless bees. The life span of the worker bees is 5-6 weeks during honey flow season however, the workers of stingless bees can live around 21 days to 2 months depending on the species.

The worker bees are also divided into:

1. **Nurse bee**: After 1 week of pupation, they become nurse bees and they are responsible for the construction of comb, secretion of royal jelly (secreted from the glands in the hypopharynx), cleaning of the hive, feeding of the queen and other developing broods or grubs.

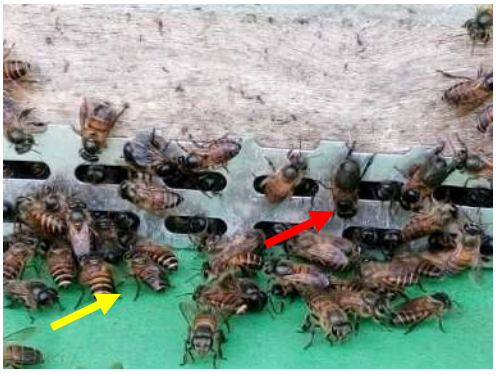
2. **Guard bee/Soldier bee**: After 1 week of nurse bee, they become soldier bee. They protect the beehive or colony from wasp and other natural enemies.

3. **Searcher bee**: After 1 week of Guard bee, they become searcher bee and they are responsible for searching pollen and nectars. They dance to give information about the source of food.

4. **Gatherer bees**: They are responsible for collecting and gathering pollen and nectars from different flowers.

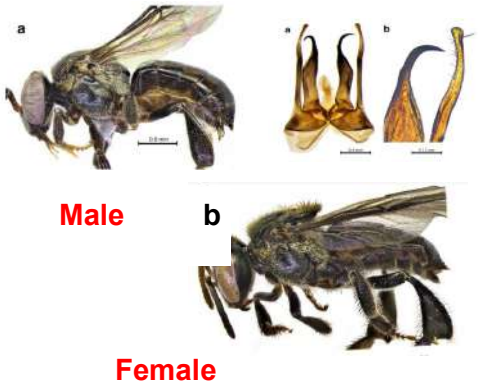
Drone: The male bees or drones are developed from unfertilized eggs. They are smaller than the queen but larger than the workers however, both male and workers bees have the same size in the case of stingless bees. They help the queen only during matting. They are only feeders and that is why more number of male bees is not desirable. They Appear in February/March and disappear in September/ October. During the off-season, drones are driven away by the workers and therefore they are not seen in the hive. Otherwise, they will consume honey from the hive. There are about 1000 numbers of drones in a colony or bee hive and a few hundred in case of stingless bee.

Queen bee



Drone (red) and worker (yellow) bees

Stingless bee Queen



Male and female of stingless bee

Skill Set (ENT) 7: Identification of silkworm species and rearing

Skills to impart : To learn different silkworm species and rearing

Sericulture is a method in which silk is reared from the silkworm cocoon. This process is also called silk reeling. Sericulture is the only industry that gives a large number of job opportunities. So, sericulture is considered a tool for the economic reconstruction of rural areas. There are various sections involved in sericulture which includes management of the mulberry garden, harvesting of leaves, rearing the silkworms, weaving which can be done by women. Approximately 58% of the employees in sericulture are women. There are many species of silkworms, which are used for commercial purposes, but the caterpillar of the silkworm, which is domesticated (also called as *Bombyx mori*) is the silkworm which is widely in use.

Silk producing moths of India

Character	Mulberry silkworm	Eri silkworm	Tasar silkworm	Muga silkworm
Species	*Bombyx mori*	*Philosamia ricini* (domesticated) *P. Cynthia* (Wild)	*Antherea perniyi* (Indian tasar), *A. mylitta*(tropical), *A. royeli* (temperate)	*A. assama*
Order	Lepidoptera	Lepidoptera	Lepidoptera	Lepidoptera
Family	Bombycidae	Saturniidae	Saturniidae	Saturniidae

Host plants	Mulberry	Castor, Tapioca, Papaya	*Terminalia tomentosa, T. arjuna, Dalbergia*	Som(*Machilus bombycina*) & Soalu(Litsaea polyantha)
Producing states	West Bengal, Kashmir, Karnataka & Andhra Pradesh	Assam	Bihar, Odisha & Madhya Pradesh	Assam

REARING OF MULBERRY SILKWORM

Mulberry Cultivation: Silkworms feed on mulberry leaves. Hence the rearing of silkworms involves the cultivation of mulberry trees, which provide a regular supply of leaves. Worms are introduced through DFLs (Disease Free Laying, i.e., eggs) procured from a quality centre (called grainage). In India, the bulk of mulberry cultivation is done by small farmers (< 4 acres of land), usually in clusters of 300-400.

For the Rearing silkworms for the following items should be made available:

Rearing house: Silkworms are very sensitive to weather conditions and temperature and, therefore, the room/building in which they are to be reared should meet certain specifications. To achieve an ideal or near ideal rearing house, avoid dampness, stagnation of air, exposure to bright sunlight, and strong winds, and ensure equable temperature, proper humidity, and ventilation.

Rearing equipments: Following are the equipments needed for the proper rearing of silkworms:

(i) Rearing stands: These are stands of frames on which are placed rearing trays containing silkworms. They could be made of wood or bamboo.

(ii) Antwells: Ants are a serious menace to silkworms. To protect them, the legs of the rearing stand are kept in rectangular/circular enamel or concrete bowls containing water mixed with some insecticide.

(iii) Rearing trays: These are trays, generally circular, made up of locally available cheap materials like bamboo. Sometimes, box type wooden trays are employed to rear early (I & II) instars.

(iv) Paraffin paper: Thick craft paper sheets coated with paraffin wax (M.P. $55^{O}C$) are required to cover the rearing trays to maintain humidity and prevent withering of leaves.

(v) Foam rubber strips: Pieces (2.5 x 2.5 cm) of foam rubber soaked in water are kept all around silkworm rearing beds to maintain humidity. Newspaper folded strips moistened with water could be a convenient substitute,

(vi) Chopsticks: Chopsticks are tapering bamboo rods meant to pick up younger stages of larvae to ensure their hygienic handling and preventing from injuries.

(vii) Feathers: Feathers, preferably white, are important items of silkworm rearing room. They are used for brushing together newly hatched worms to prevent injuries.

(viii) Leaf chamber: Mulberry leaves meant for feeding are stored in chambers made up of 7.5 cm wide wooden strips fixed some distance apart or of some porous board. The chamber with leaves is covered all over with gunny bag cloth kept moist during the

summer months and dry days.

(ix) Chopping boards, knives and mats: As mulberry leaves are offered to the worms in a chopped condition, chopping boards, knives and mats are required.

(x) Cleaning nets: Nets made up of cotton or nylon of the mesh size suitable for different instars are used for changing the rearing beds so that the left-over leaf-pieces and litter are filtered out without the larvae being touched by hand. Manual separation of larvae from the litter has the risk of injuring and killing many of them. Mesh sizes suitable for I, II, III & IV, and V instars are 2 mm^2, 10 mm^2 and 20 mm^2, respectively.

(xi) Mountages (cocoonages, Hindi- chandrikes) are contrivances made up of rectangular bamboo mat tied on 4 bamboo sticks and bearing on its surface spirals of bamboo tapes. Ripe worms about to spin cocoons are transferred on to them. The larvae suspend themselves to the spirals and spin cocoons.

(xii) Miscellaneous appliances: These include a hygrometer to measure humidity, a thermometer to record temperature of the rearing room, a charcoal stove to heat the rooms in winter, disinfection pads of gunny soaked in 2% formalin to disinfect the feet of the workers entering the rearing room, a sprayer to disinfect the rooms themselves, wooden stands of crossed legs to place trays during feeding and bed cleaning, a stand for wash-basin containing 2% formalin to disinfect the hands of the workers handling the worms and leaf – baskets to transport mulberry leaves.

Quality seeds:

Quality seeds (silkworm eggs) can be obtained from grainages which are centres for the production of disease–free seeds of pure and hybrid races in large quantities. Pupae randomly obtained from the seed cocoons are crushed in a mortar with a pestle and examined under a microscope for pebrine or any other diseases. After ensuring that the stock or crop purchased is free from any disease, cocoons are selected conforming to specified characteristics are taken and others that are deformed, flimsy, stained, or dead, are rejected. Moths usually emerge during the early morning hours. To bring about a near-simultaneous emergence, grainage rooms are kept in the dand on and the expected day of emergence, lights are put on suddenly. Emerging moths are sexed and used as reproductive seeds. Three hours of mating secures maximum fertilized eggs. Male moths are then stored at 5°C to be used for a second mating while the female moths are kept in cellules for egg laying. Within 12 hours, 400-600 eggs are laid. Each layer is then crushed and examined for pebrine. If infected, its eggs are discarded and destroyed. Generally, females are made to lay eggs on paper sheets or cards whose surface has been coated with a gunny substance. The egg sheets/cards are washed with 2% formalin for 1 hour to disinfect the eggs and again with water to remove traces of formalin. The sheets are dried in the shade and transferred to incubators for hatching. In commercial production, 50-100 moths are allowed to lay eggs on paper sheets. The egg sheets are soaked in water to loosen the eggs. The loose eggs are washed in salt solution to remove unfertilized eggs which float on the surface. The fertilized eggs thus separated are disinfected with 2% formalin, shade dried, and packed (loose) in egg boxes to be dispatched to buyers (seed producers).

Quality of food:

Growth of silkworms depends on the right kind of mulberry leaves obtained from the yielding high-yielding mulberry varieties. Younger (I & II) instar larvae are to be given tender succulent leaves with a high moisture content and the older instars, mature but soft leaves with lesser moisture content.

Shape and size of leaves:

Mulberry leaves fed to the larvae in a chopped condition. Chopped leaves have certain advantages over the entire leaves: (i)chopped leaves can be spread evenly, the quantity of feed can be regulated, and the results assessed, (ii)they prevent silkworm beds from getting damp in wet weather, and (iii) they do not curl up when the weather is dry.

Preparation of feed bed:

A feed bed or simply bed is a layer of chopped leaves spread on a tray or over a larger area. Finely chopped mulberry leaves are evenly scattered on the paper and the larvae carefully brushed on to the leaves. A second sheet of paraffin paper is placed loosely over the bed and in between the two sheets and on all sides water-soaked foam-rubber-strips (or wet newspaper folds) are placed to maintain the humidity. In place of trays, wooden boxes (10-15 cm deep and of convenient sizes) with or without lids can be used. The boxes could be stacked one above the other but separated by thin wooden strips for ventilation. The older (III-V) instars can be reared by 3 methods: shelf-rearing, floor-rearing and shoot-rearing. In shelf-rearing, silkworms are reared in round bamboo trays arranged one over the other in tiers on a rearing stand. A stand can accommodate 10-11 trays and, therefore, this method provides economy of space but requires more labour for handling so many individual trays. The larvae are fed on chopped leaves in this method. In floor-rearing, fixed rearing seats or benches, 5-7 x 1-1.5 m size, constructed in 2-3 tiers out of wooden or bamboo strips, are used for rearing the silkworms. In shoot rearing, the rearing seat, 1 m wide and any length long, is in single tier and the larvae are offered big shoots. To change the bed in this method, ropes parallel to each other are stretched on the old bed and new shoots are placed on these ropes. When all the larvae have climbed on to the new branches, the ropes are rolled into loose bundles, the old bed and litter cleaned and the ropes and the branches spread again, making a new bed. Recent findings show that 4 feeds a day are sufficient for each instar. The feeds are normally given at 9 AM, 1 PM, 5 PM and 10 PM.

Bed cleaning:

Periodical removal of leaf leftovers and worm excreta is referred to as bed cleaning. It is necessary not only from the hygienic point of view but also from the point of proper growth of the larvae. Four methods are adopted for this purpose: conventional method, husk method, net method and the combined husk and net method.

Spacing:

Spacing means avoiding overcrowding of caterpillars by increasing the size of the feeding trays with the growth of the insects. It would save time and labour if the spacing is combined with bed cleaning. Spacing could achieved by making out the extended feed area and distributing both the leaves and worms evenly over the entire area. Besides, crowding increases accumulation of gases, heat, and fermentation of fecal matter, particularly during the early stages when the temperature and humidity in the rearing beds are high. Such unhygienic conditions may lead to infection, death, and loss of crops.

Moulting:

When about to molt, the larvae attain their maximum size for the particular instar. At this stage, bed cleaning should be carried out and leaves should be chopped to a small size for pre-molt feeding. When the larvae settle down for molting, feeding stops. During molting, the worms are most susceptible to muscardine infection which could be prevented by dusting them with cerasan + lime.

Mounting and harvesting:

Transferring mature V instar larvae to mountages (cocoonages or chandrikes) is called mounting. When the larvae are fully fed and ripe, they become translucent, their body shrinks, they stop feeding, and start searching for a suitable place to attach themselves for cocoon spinning and pupation. They generally move to the periphery of the rearing tray for this purpose. This is the right time to pick them up and put them on mountages. The worms attach themselves to the spirals of the mountages and start spinning cocoons. It is necessary that only the right age larvae are put on the mountages and a correct density be maintained to avoid crowding.

Care during cocoon spinning:

The quality of the cocoon spun by the larvae depends to a great extent on the temperature, humidity and proper ventilation at the time they are being spun. The optimum temperature of the room at this should be 24˚C, and the humidity 60-70 per cent. Abnormally high and low temperatures adversely affect the health of the worms and make the resulting cocoon unfit for seed purposes. Likewise, too much humidity spoils the luster of the filamenttond too dry an air depilates the worms. Similarly, ventilation of the room should be such that humidity is reduced but the worms are not exposed to violent draught of wind or to direct sun.

Harvesting of cocoons:

When the caterpillar has spun its silken cage or cocoon around itself, it castes off its skin to pupate. In early days, pupal skin is tender and ruptures easily. Therefore, early harvest of the cocoons could injure the pupae and result in their blood not only soaking in and staining the former but also inducing fermentation and infection and making the stained portion unreelable. Late harvest, on the other hand, leaves less time for transporting the cocoons to the market and so for their stifling with the result that they will run the risk of being cut by the emerging moths and thus being rendered unfit for reeling. Harvesting is normally done by hand.

Post-harvest processing of cocoons:

These post-harvest processing steps are (i) stifling (ii) boiling (iii) brushing (iv) reeling (v) re-reeling (vi) finishing and (vii) testing.

(i) Stifling: The purpose of stifling or cocoon drying is to kill the pupae before they metamorphose into moths and emerge, cutting the cocoons and rendering them unreelable. This is achieved by any of these 3 methods: drying cocoons under the sun, hot-air stifling or steam–stifling.

(ii) Cocoon boiling: This is done to make the cocoon thread lose by dissolving the gum-like protecting sericin that binds the winding segments of the thread.

(iii) Brushing: Brushing is done to seek the free end of the silk filament in the cocoon. It could be achieved manually or by mechanically operated brushes.

(iv) Reeling: This is the process of unwinding the silk thread or brins from the cocoons, combing the required number of brins to produce silk filaments of a required thickness, and gathering the same on standard reels.

(v) Re-reeling: The raw silk is first reeled on small reels, allowed to properly dry up on them, and then re-reeled on large reels.

(vi) Finishing: In this process, the visible defects of the raw silk thread-like oversize knots, loose ends etc. are removed and the silk is boiled, stretched, purified by acid or by fermentation and repeatedly washed to bring out the luster of the silk. The threads are then changed into bundles or skeins. A skein of silk has a diameter of 1.5 m and a weight of 70 gm.

(vii) Testing: There are Indian and International standards to judge the quality of the raw silk and facilitate its marketing. To maintain these standards, raw silk is put to several tests to assess its size variations, winding quality, neatness, evenness, cohesion, and tenacity.

Reeling appliances:

Three types of reeling methods are currently in vogue in India: *country charkha*, *cottage basin,* and *filature*. However, the basics of all of them are the same *viz*., the stifled cocoons are heated (or cooked in sericulture parlance) in boiling water to dissolve the gummy sericin, remove the puff, and loosen the silk filament. The free end of the filament is teased or brushed free, and the free ends of 5 – 10 cocoons are passed through the hole/holes of a spool or button to be twisted into a single thread and wound on a reel.

Skill Set (ENT) 8 : Rearing of eri silkworm

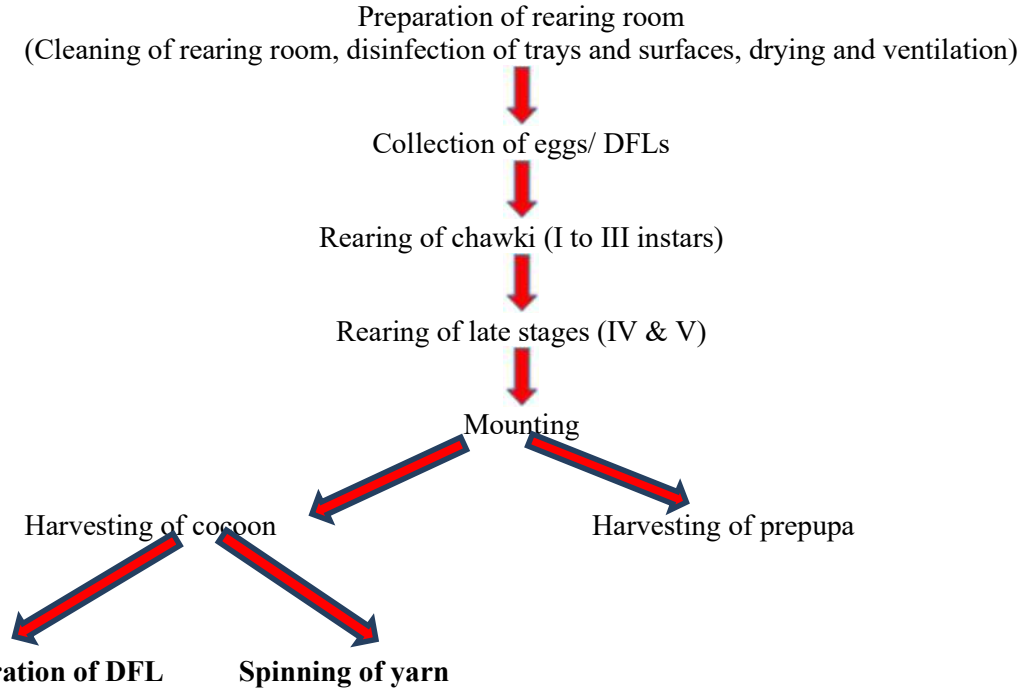
Skills to impart : Scientific rearing of Eri silkworm for cocoon and prepupa production

The Eri silkworm, *Samia ricini* (Donovan) is the only domesticated commercially exploited non-mulberry silkworm adopted for indoor rearing round the year. This species of silkworm is known to be reared in different parts of the world with diverse expectations for its silk fibre, food and biomaterials. In India, Eri silkworms are reared in many parts particularly in northeast region. Eri culture is a household activity practiced mainly protein rich pupae, a delicacy of the tribal communities of northeast region and the silk is used for preparation of chaddars (wraps).

MATERIALS REQUIRED

Host Plant	:	Castor (*Ricinus communis*), kessaru (*Heteropanax fragrans*), cassava (*Manihot esculenta*)
Non-recurring items	:	Rearing trays, wet & dry thermometer, plastic mountage/ dry twigs/ paper pulp egg tray, camel hairbrush
Recurring items	:	Butter paper, bleaching powder, lime powder, ant repellent chalk, formalin, muslin cloth, black box

PROCEDURE:



Task 1: Preparation of rearing room

- Room cleaning
- Disinfection of surfaces
- Cleaning and disinfection of trays and other types of equipment
- Drying and ventilation

Task 2: Collection of eggs/ DFLs

Task 3: Rearing of chawki

- Rearing of young instars of silkworm (I to III instars)
- Young instars should be fed with tender young leaves of castor
- 2 times feeding (morning and evening)

Task 4: Rearing of late stages

- Rearing of IV and V instars
- Voracious eaters so feeding should be dome at least 3 times a day or as per requirement
- Older leaves of castor that are cleaned properly should be fed
- Matured V instar larvae should be separated and transfer to mountage for cocooning
- Index for maturity is straw yellow colour, transparent body with hollow sound when rubbed

*Rearing activities include the following:

i. Recording temperature, humidity and rainfall parameters
ii. Feeding
iii. Bed cleaning and division of rearing trays with subsequent larval stages
iv. Examining larvae for moulting stages and diseases
v. Shifting of mature larvae to cocooning room

Task 5: Mounting

- Transfer matured V instar larvae to mountage for cocooning
- Different mountages can be used according to availability. E.g. plastic collapsible mountage, egg trays, tree branches, etc.

Task 6: Harvesting of cocoon and pre-pupa

- Harvesting cocoon
- Cocoons can be harvested by careful handpicking from the mountages
- Pre-pupa harvesting
- Eri silkworm cocoon is an open cocoon, so the pre-pupa can be easily harvested from the open side

Task 7: Preparation of DFL

- Selection of healthy parent stock
- Isolation and quarantine

- Sanitization
- Mating and oviposition
- Egg collection and storage

Skill Set (ENT) 9 : Collection and preservation of insects

Objectives: To study the process of insect collection, killing, pinning, setting, labeling and preservation for identifying the insects.

Procedure:

The insects are found everywhere and can be collected from different ecosystems. Different equipment and collection methods can be used depending on the group of insects and their habitats. The collected samples are killed and different curation methods are followed which include preservation and labeling of the insects.

A. Collection of insects

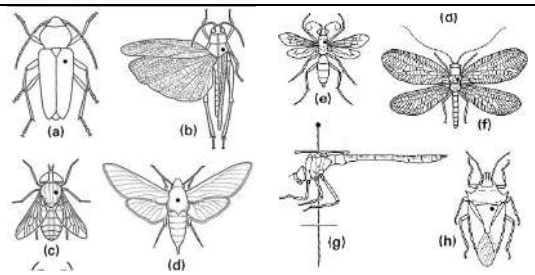
<table>
<tr>
<td>Activity-1: Handpicking
For bigger size insects

Activity-2: Sweeping using insect net for flying insects
The handle is turned by quick turn of the wrist to fold the bag over hoop to prevent the escape of trapped insects.</td>
<td> 
Activity-1
 
Activity-2</td>
</tr>
<tr>
<td>Activity-3: Trapping
• Light trap for nocturnal insects
• Pitfall trap for soil-dwelling crawling insects
• Berlese funnel for soil-dwelling or insects living in leaf litter
• Aspirator for small active insects</td>
<td>   
    </td>
</tr>
<tr>
<td>Activity-4: Killing of insects
Killing jars with ethyl acetate</td>
<td>  
</td>
</tr>
</table>

B. Preservation

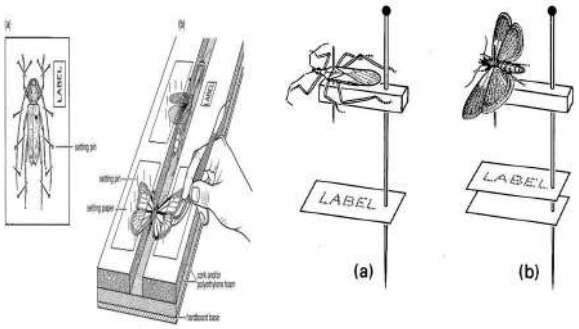
Mounting and preservation of insects

Activity-1: Pinning of insects
Hard-bodied insects are pinned with entomological pins made of steel with chromium polish to avoid rust. These pins are of various sizes and insects are pinned vertically through the body. Pinning areas are specific for different insect orders.



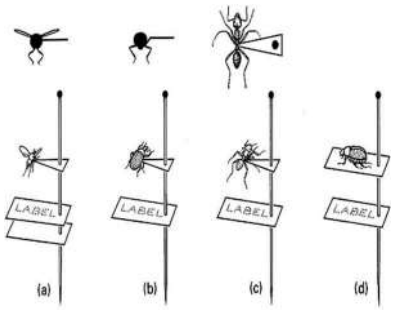
Activity-2: Setting/spreading of insects

- Method of setting depends on the type of insect
- In butterflies, moths and mayflies, the rear margins of the forewing should be straight across at the right angle to the body and the hind wing should be far enough forward that there is no large gap at the side between the fore and hind wings



Activity-3: Double mounting for smaller insects

- Staging
- Carding
- Pointing



Activity-4: Labelling

- A specimen carries no meaning at all if it is not properly labeled. While labeling at least the following points should be noted:
  Name of host plant; locality of collection; date of collection; name of collector

Activity-5: Liquid preservation

- For preserving soft-bodied insects, mature as well as the immature stage at 70% ethyl alcohol

Skill Set (ENT) 10 : Identification of insects of different orders

Objectives: To identify important insect orders which is agriculturally important insect groups.

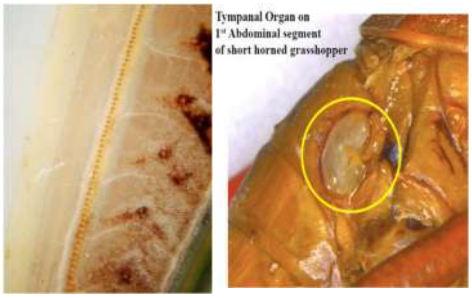
Procedure:

The insects are collected and preserved as wet preservation or dry preservation as per requirement at the time of identifying the insects.

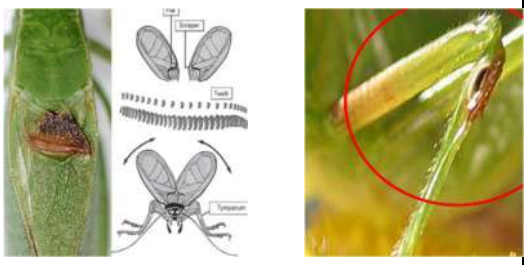
A. Identification of insects belonging to order Orthoptera

Activity-1: Identification up to order
- Hypognathous head
- Biting and chewing type of mouth part
- Forewings modified to tegmina; hindwings membranous
- Saddle-shaped pronotum

Activity-2: Identification of the family Acrididae
- Antenna shorter than body
- Tympanal organ on either side of first abdominal segment
- Stridulation femora-alary type



Activity-3: Identification of family Tettigonidae
- Antenna as long as or longer than the body
- Tympanal organ on foretibia
- Stridulation alary type
- Ovipositor sword like



B. Identification of insects belonging to order Lepidoptera

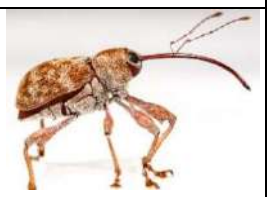
Activity-1: Identification up to order
- Siphoning type of mouth part, long coiled proboscis in adults; larvae with mandibulate mouthparts
- Wings membranous, covered with overlapping pigmented scales

Activity-2: Differentiation between butterfly and moth
- Butterflies fold their wing vertically upward when at rest; diurnal
- Moths hold their wings flat or roof-like over their body when at rest; nocturnal

C. Identification of insects belonging to order Coleoptera

Activity-1: Identification up to order

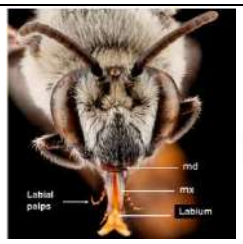
- Head normal or prolonged
- Mouth parts chewing type
- Forewings are horny known as elytra, hindwings membranous and folded under elytra

D. Identification of insects belonging to order Hymenoptera

Activity-1: Identification up to order

- Mouth parts chewing and lapping
- Wings stiff and membranous
- Propodeum (fusion of metathorax and first abdominal segment)



E. Identification of insects belonging to order Diptera

Activity-1: Identification up to order

- Mouth parts sucking type (piercing and sucking and sponging type)
- Hindwings modified into halteres



F. Identification of insects belonging to order Hemiptera

Activity-1: Identification up to order

- Head is opisthognathous
- Mouth parts piercing and sucking type

Activity-2: Differentiation between heteropteran and homopteran insects

- In heteropterans, head is horizontal; scutellum well developed; forewings modified to hemelytra; wings fold flat over body
- In homopteran insects, head is deflexed; forewings uniform; wings held as roof like over body




Skill Set (ENT) 11 : Management of beneficial insects

Objectives: To know the beneficial insects as they play a vital role in agriculture and ecosystem management. To study the positive impact, they have on various aspects of the environment, particularly in pest control, pollination, its entrepreneurship platforms.

Procedure:

1. Identify all the honeybee species which are important in beekeeping and understand all the principles and criteria for apiary management.

2. All beneficial insects like silkworms and lac insects are identified and different aspects of rearing are studied.

3. *Tricogramma* are mass-reared in laboratory by using *Corcyra* eggs and Trico cards are prepared.

A. Apiculture

<table>
<tr><td colspan="2">1. Honeybee rearing</td></tr>
<tr><td>Activity-1: Identification of domesticated honey bee

Apis cerana: Workers are black in colour, with four yellow abdominal stripes and built multiple comb
Apis mellifera: Workers are black, with three yellow abdominal stripes and built multiple comb
Stingless bee: they are smallest honeybee and have stingers, but they are highly reduced. There is no definite structure of comb</td><td>     </td></tr>
<tr><td colspan="2">2. Environment requirement and site selection for apiary & General apiary management</td></tr>
<tr><td>Activity-1: How to develop apiary
• Easily accessible by road
• Fresh running water near the apiary
• Natural or artificial wind breaks
• Hives can be kept under shade of trees
Activity-2: Hive inspection
• Handling of honeybee colony
• Expanding brood net
• Swarm control
• Artificial feeding
• Uniting bee colonies
Handling of queen</td><td></td></tr>
</table>

3. Equipment necessary for honeybee rearing	
Activity 1: **Uses of beekeeping appliances** **Beebox**: Newton for *Apis cerana* Lengstroth for *Apis mellifera* **Swarm catcher**: For catching bees **Bee veil:** For the protection of facial area during handling **Gloves:** For protection of Hand **Smoker:** To make calm the honeybees **Honey extractor:** To extract honey	   
Development of bee floral garden	
Activity: Selection of nectar and pollen supplying plant Growing of season or year wise bee floral plant eg. mustard, sunflower, orange, litchi, apple, lemon, buckwheat, rubber etc.	
Seasonal Management of Honey bee colony	
Activity-1: **Seasonal management** **Summer season**: Keeping wet gunny bags over the top cover and sprinkling water on and around the colonies **Winter season**: Keeping gunny bags over the top cover **Rainy season**: Weak colonies should be united with stronger ones, provide artificial food **Spring season**: Swarm prevention, Colony multiplication **Activity-2**: **Insect Pest Management** **Wasp**: Flapping, Trapping them through fish/meat/molasses trap Providing wire gauge screening in front of the hive entrance **Wax moth**: Dusting of sulphur @ 2gm per hive over the top bar, Use of biopesticide viz., Bt formulation var. karstaki @ 0.5gm /lit water/hive	   

Activity-3: **Disease management** **Thaisac brood**: • Dequeening and requeening • Treated with antibiotics like oxytetracyclin 250mg @ one tablet per 4 litre of sugar solution **Nosema**: Infected colony is treated with Entakon-M@45.5ppm (one tablet per liter of sugar solution) at weekly interval	

B. Sericulture

Identification of silkworm species	
Activity: How to identify silkworms for rearing **Mulberry silkworm:** Adults are whitish, cocoons are tight **Muga silkworm:** Can not rear indoors, Female adults are yellowish to brown, golden or light brown, rudimentary peduncle **Tasar silkworm:** Cocoon are with peduncle and different colour pale gold, pinkish honey, creamy copperish etc **Eri silkworm:** Cocoons are open mouthed, colours ranges from white to various shades of green and brown	   
Equipment required	
Activity: Use equipment for silkworm rearing Rearing bed, Mountages for spinning, Leaf picking bags, chopping knives, chopping boards, Chopping table etc.	 
Selection of host plant	
Activity: Plants required for silkworm rearing Mulberry plant (mulberry) Som, Sualu (Muga) Oak (Tasar) Castor, Kessuru (Eri)	

Te raring process of silkworm	
Activity 1: How to rear silkworm **Chawki rearing** (I to III instar larvae). Feeding with nutritious tender leaves of the host plant to get a healthy stock of silk worm Late age rearing of mulberry silkworm (IV and V instar larvae) This stage of worms consumed about 90 to 95 percent of the total feed. **Activity-2:** Spinning of cocoon**:** Mountage required for spinning of cocoon **Activity 3: Harvesting of cocoon:** After pupation, when the integument of the pupa turns brown and hard on the 5th day, the cocoons may be harvested.	  

C. Lac Culture

Identification of lac insect	
Activity: How to identify lac insect Lac insect lives in cavities made in the resin or lac secreted by them on their host plant	
Rearing of Lac	
Activity 1: Host plant for lac cultivation Babul, Pipal, Palas, Kusum, Khair, sirrus etc), three species namely, Palas (*Butea frondosa*), Kusum (*Schlechera oleasa*) and ber (*Zizyphus jujuba*) **Activity 2: Lac brood inoculation** • Lac cultivation is done by putting brood lac on suitably prepared specific host plants. • After the emergence of the mother cell, the young larvae settle on fresh twigs of the host plant, suck the plant sap and grow to form encrustation. **Activity 3: Processing of Lac** • Stick lac: Stick lac or raw lac or scrapped lac. • Seed lac: Processed lac • Shellac It is the finished product of lac orange to pale yellow in color	

Skill Set (Ento) 12: Preparation of Botanicals

Objectives: To use organic materials to control insect pests and diseases.

Materials required:

1. Neem seed kernels (well dried) – 5 kg
2. Water (reasonably good quality) – 100 litres
3. Detergent - 200 g
4. Muslin cloth for filtering

Procedure:

1. Take the required quantity of Neem seed kernel (5 kg)
2. Grind the kernels gently to powder it
3. Soak it overnight in 10 litre of water.
4. Stir with a wooden plank in the morning till solution becomes milky white
5. Filter through double layer of muslin cloth and make the volume to 100 litre
6. Add 1% detergent (Make a paste of the detergent and then mix it in the spray solution)
7. Mix the spray solution well and use.




Preparing for spraying solution

1. Neem Kernel extracts (500 to 2000 ml) are required per tank (10 litres capacity). 3-5 kg of neem kernel is required for an acre. Remove the outer seed coat and use only the kernel. If the seeds are fresh, 3 kg of kernel is sufficient. If the seeds are old, 5 kg is required.
2. Pound the kernel gently and tie it loosely with a cotton cloth. Soak this overnight in a vessel containing 10 litres of water. After this, it is filtered.
3. On filtering, 6-7 litres of extract can be obtained. 500-1000 ml of this extract should be diluted with 9 litres of water.
4. Before spraying khadi soap solution @ 10 ml/litre should be added to help the extract stick well to the leaf surface. This concentration of the extract can be increased or decreased depending on the intensity of the pest attack.

PLANT PROTECTION (PLANT PATHOLOGY)

Skill Set (PP) 1: Diseases associated with bacteria, fungi, viruses and nematodes from the field

Skills to impart: To collect diseases due to bacteria, fungi, viruses and nematodes in the field

Plant disease is a condition of impairment from the normal state of living, which could arise due to either constant association of biotic agents (Fungi, bacteria, viruses, nematodes, protozoa, etc.), abiotic factors, inherent defects of the plants or a combination of these. Diseases can be identified by the various symptoms displayed by the host and the physical signs of the associated causal agents. Collectively, these symptoms and signs constitute the disease syndrome. Biotic causal agents, known as pathogens, include fungi, bacteria, viruses, viroids, nematodes, protozoans, and parasitic higher plants. Abiotic causal agents encompass extremes in temperature, moisture, nutrients, and light, as well as soil pH imbalances, air pollution, oxygen deficiency, pesticide toxicity, and improper cultural practices.

Various symptoms associated with plant diseases:

Symptoms		Possible cause
	Leaf Spot	Fungal, bacterial, or viral infection
	Blights	Fungi, bacteria, or nematode infection
	Canker	Fungi or bacterial infection
	Rots	Fungi or bacterial infection or due to excess moisture
	Galls	Bacterial infection, nematodes
	Smut	Fungal infection
	Blister	
	Mildew	
	Vein Clearing	Viral infection

	Ringspot	
	Enation	
	Stunting	Fungi, bacteria, virus and nematode infection
	Wilt	Fungi, bacteria, nematode infection

Tools which are required for plant disease sample collection

1. Plastic and paper bags,	2. Trowel, pencil,	3. Padded collection boxes,	4.Labels,
5. Disinfectant for hands & tools	6. Camera, hand lens	7. Wire twist ties	8. Knife
9. Pruning shears,	10. Rubber bands	11. Field Manuals	12.Gloves

Procedure for collection of disease samples associated with fungi, bacteria, and viruses

1. Examine the entire plant for symptoms: Examine all major plant organs such as roots, stems, leaves, and blossoms for disease symptoms. Collect samples from various plant organs as necessary, keeping in mind that plants can suffer from multiple diseases simultaneously. Separate samples based on different symptom types.
2. Collect Fresh Material: Obtain enough fresh material that exhibits various symptoms of the disease. Include as many identifiable stages of the disease as possible, focusing on the most recently developed symptoms for the best diagnostic material.
3. Do not collect dead plants or plant organs: Dead plants or plant organs may not be useful for diagnosis because their tissues are often invaded by decomposing fungi and bacteria, making it difficult to detect the original pathogens
4. Lift Roots carefully: Avoid leaving behind feeder roots or rotted roots. Include about a liter of soil for testing pH, soluble salts, and possibly conducting a nematode assay.
5. Collect the entire plant: If the collected part of the plant is wrong, the diagnosis couldn't be done properly. So, it is advisable that the whole plant is collected by carefully digging out from the soil.
6. Prevent Soil Contamination: Use a wire twist-tie to secure the stem at the ground line, preventing soil from contaminating above-ground plant parts. Accurately label the samples and place them in a paper bag or an unsealed plastic bag.
7. Gather Information: Various information such as, Name of the Grower, Date of Collection, Name of the crop host and variety, Statement of Problem, Growers' Telephone Number needs to be recorded and include with the sample submission form. It is important to gather the best plant samples possible and to record all pertinent background information for the diagnostician.
8. Package Samples Appropriately: Properly packaging samples is crucial to ensure they arrive in good condition at the plant clinic. Follow these general guidelines for handling and packaging plant and insect samples:

9. Use Plastic Bags: For most samples, including leaves, stems, and roots, use plastic bags to prevent them from drying out during transport. For fleshy fruits, vegetables, or tubers in stages of decay, wrap them individually in dry newspaper.
10. Do Not Add Extra Water: Avoid adding any water or moist paper towels, as moisture promotes the growth of fungi and bacteria that can decay plant tissues and obscure the diagnosis of the pathogen.
11. Label the Samples: Write your name, telephone number, and the name of the plant or sample number on the plastic bag using an indelible marker. Alternatively, write the information on a piece of paper and insert it into the bag.
12. Segregate Plant Tissue and Insects from Soil: Keep soil off the foliage and ensure plant or insect samples and information labels do not come into contact with any soil in the plastic bag, unless the sample is a soil-dwelling insect.

Procedure for collection of disease sample associated with nematodes

Why to collect soil sample?

Soil samples provide an estimate of plant parasitic nematode populations in the soil and may be preventative or diagnostic

When to collect sample?

Sampling can be conducted at any time of year; however, careful interpretation of results is critical as populations can vary based on soil type, season, and crop grown

Where and how to collect sample?

For preventive sampling, collect random samples in a zigzag or w-pattern across the field.

Most of the plant parasitic nematodes live in rhizosphere of the host plants and mostly they are not evenly distributed in a field, therefore, some of the subsamples should be collected each field where sampling to be performed.

1. Sampling from field with crops or without standing crop

- 1-meter peripheral area of the sampling field must be left.
- Remove the 2-3 cm upper layer of the soil with the help of a khurpi or any other hand hoes.
- Collect about 50 grams of soil along with feeder roots (sub-sample) up to a depth of 15-20 cm.
- Draw 10-20 such subsamples from 1 ha area in a zig-zag manner covering the entire area of the sampling field.
- Mix all the subsamples in a bucket/polythene bag (composite sample); the total weight of the composite sample should not be less than 500 g and pack in the polythene bag.
- Write the sample details on the label.

2. Sampling from Orchard

- Collect two subsamples from one tree up to a depth of 30-60 cm.
- Collect subsamples from around 10 trees randomly from a one-hectare area.
- Mix all the subsamples (composite sample) and label it.

3. Labelling

The following information should be labeled on each composite sample collected

- Date of sampling
- Farmer's name and complete address on which report is required
- Phone number
- Sampling site (preferably GPS location): Village, Block, District
- Standing crop name
- Previous crop history (name of the crops grown)
- Symptoms observed, if any

4. Storage of Samples

Samples should be stored in a refrigerator at 10° C for up to 10 days or stored in a cool place away from direct sunlight.

Skill Set (PP) 2 : Diagnostic and detection methods for plant diseases

Skills to impart : To learn different diagnostic methods of disease detection

Detection: Disease detection involves a set of procedures used to determine the presence of a pathogen in infected tissues. However, these procedures may not always fully identify the pathogen.

Diagnosis: Disease diagnosis refers to the process of identifying a disease or determining the agent responsible for causing the disease. A complete diagnosis involves identifying both the disease and its causative agent, which is confirmed by applying Koch's postulates to establish pathogenicity

Why disease diagnosis is important?

Disease diagnostic procedures reveal the initial inoculum present in a sample, which is crucial for studying the spread of the disease and understanding the epidemic. Early detection of pathogens allows for the timely implementation of control strategies, preventing the development of damaging epidemics. Without accurate identification of the disease and its causative agent, disease control measures can be ineffective, wasting time and money, and potentially leading to further plant losses. Therefore, proper disease diagnosis is essential.

What are the principles of field diagnosis?

Before going to diagnosis for any plant disease, it is important to know how healthy plant look like or understand the normal appearance of a plant species, as each species has distinct growth habits, colors, and growth rates. Once the "normal" appearance of a specific plant is determined, it becomes possible to compare healthy plants with those showing problems.

Steps in diagnosis of plant diseases at field:

It is important to examine the plant, while considering the following points

a. Presence of any symptoms: Look for any visual symptoms such as **s**tunting, chlorosis, galls, necrosis, wilts, dieback, spots, rots, blights, blisters, mosaic, enations, vein clearing, witches broom in the plant.

b. Presence of signs: Signs include fungal mycelia, fungal spores, and spore-producing bodies such as mildew, pustules, sclerotia, smut etc. Signs are more specific to disease-causing agents than symptoms and are extremely useful for diagnosing a disease and identifying the causative agent.

c. Identification of affected plant parts: Does the disease symptom occur only to a specific plant part or throughout the plant system.

d. It is important to note the field condition and the cultural practices being followed in the cropping season.

Important precautions to be undertaken:

a. Possibility of multiple pathogen infection: Variations in symptoms exhibited by diseased plants can be due to the presence of more than one infecting a plant. The symptoms in such cases can differ substantially from those caused by each pathogen individually.

b. Disease due to other factors: When diseases are caused by pathogens, it is rare for all plants to be affected. Uniform patterns on individual plants and consistent damage over large areas are typically due to abiotic factors like soil conditions, adverse climatic conditions or chemical toxicity. Also, if the same disease occurs in multiple host species in the field, there is high chance that it might be due to a non-abiotic cause.

c. Herbicide injury: In diseases caused by biotic agents, symptoms will progress and spread to other plant parts or newly emerging leaves. However, in the case of herbicide injury, symptoms may appear similar but will not progress to other parts of the plant or new leaves.

When the symptoms and signs present in the plants are insufficient for the field diagnosis of the disease, it might be necessary to bring the sample in the laboratories for isolation and identification of the causal agent.

Different diagnostic methods of plant diseases are:

A. Conventional methods

1. **Microscopy:** As most of the plant pathogens that cause disease in plants are minute in size and cannot be visible with an unaided eye, microscopes are an important tool for visualizing fungal hyphae, spores, fruiting bodies, and bacterial pathogens. For an accurate diagnosis, high-precision microscopes are essential and widely used instruments. By examining the infected plant parts under a

microscope, it is often possible to diagnose the disease by observing the hyphae, microsclerotia, conidiophores, conidia, and bacterial cell clusters of pathogenic fungi and bacteria.

Compound microscope: There are various types of microscopes based on its operation, but the basic structure consists of an optical system for magnification and an illumination system for rendering the specimen properly visible. The magnification power of a compound microscope is up to 40X - 1000X with a resolution power of 0.25 µm. Different parts of a basic compound microscope.

Electron microscope: For observation of plant viruses, electron microscope is used which have very high magnification power of up to 50,000,000X and has a resolving power of up to 0.2 nm.

Even though microscopes are very useful tools, most of the time visual observation alone is insufficient to identify the pathogen. Therefore, additional mycological examinations, such as the moist chamber technique and biological assays, need to be performed.

2. **Moist chamber method**: In the moist chamber method, diseased plant parts are placed in a high-humidity environment, such as Petri dishes, and incubated. This method involves the following steps:
    a. A blotting filter paper is laid in sterile Petri dishes,
    b. Sterile glassware is placed on top,
    c. Infected plant parts (such as cut pieces of fruit, leaves, roots, etc.) are placed on the glass.
    d. The Petri dish is then closed with a cover and incubated at 24-28°C.

By observing the hyphae, macroconidia, and microconidia obtained through this method under a microscope, it is possible to identify pathogenic fungi or fungal organisms to the level of genera and species.

3. Biological assays: This method is mainly used for the diagnosis of plant viruses, and viroid. Various plant pathogenic viruses produce specific symptoms when inoculated into indicator host under environmentally control conditions. The major disadvantage of this method is long incubation time and need for special isolation chambers for performing virus inoculation. Some of the examples of indicator host for conducting biological assays are Mexican lime for *Citrus tristeza virus,* Sweet orange for Citrus greening, Etrong citron for *Citrus exocortis viroid.*

B. Modern techniques for diagnosis of plant diseases

1. **Serological techniques**: This method is based on the specific reaction between antigens and antibodies. It detects the presence of small molecular compounds, viruses, and their quantitative indicators. Immunodiagnostics, or serological methods, include techniques such as agglutination, radial immunodiffusion, Enzyme-Linked Immuno Sorbent Assay (ELISA), Dot Immuno Binding Assay (DIBA), Western blotting, Lateral flow assay

Enzyme-Linked Immunosorbent Assay (ELISA):

ELISA is one of the most commonly used serological techniques for the detection and diagnosis of various plant pathogens such as viruses, fungi, bacteria, phytoplasma. It used to detect the presence of an antibody or an antigen in a sample. In ELISA, an unknown amount of antigen or antibody is affixed to a surface, and then a specific antibody or antigen is washed over the surface to bind with the corresponding antigen or antibody. The detecting antibody is linked to an enzyme. In the final step, a substrate is added, and a detectable signal is generated due to the catalytic reaction. By measuring the optical density (OD) value, the presence of the antigen or antibody can be detected. The enzyme linkage allows for the detection of the target protein and, if present, enables quantification

because the signal intensity is directly proportional to the protein quantity. Most commonly used type of ELISA are direct antigen coated (DAC) and double antibody sandwich (DAS) ELISA.

Molecular methods: One of the most important and routinely used technique for plant disease detection and diagnosis across the globe is polymerase chain reaction (PCR). This method is rapid, highly sensitive and effective method for disease identification up to species level.

Skill Set (PP) 3 : Mushroom spawn production

Skills to impart : To learn production techniques of spawn production

What is spawn?

Mushroom spawn is a substrate that already has mycelium growing on it. Mycelium or actively growing mushroom culture is placed on growth substrate to seed or introduce mushrooms to grow on a substrate. Spawn may be called as seed of mushroom. Like seeds of the crop plants, mushroom cultivation starts from spawn, the vegetative seed material

Solid spawn production technology of oyster mushroom (*Pleurotus* sp.)

Pleurotus spawn can be prepared using any kind of cereals grains: Paddy. Wheat, Jowar, Bajra, Rye etc. Grain should be free from diseases, should not be broken, old and free from damage by insect pest

Materials Required:

1.Rice grains, 2. LPG Burner/ Electric stove, 3. Laminar flow, 4. Calcium carbonate, 5. Calcium sulphate, 6. Non-absorbent cotton, 7.PVC bags, 8. Buckets and miscellaneous, and 9. *Pleurotus* culture

Step by step process for oyster mushroom spawn production

Wash the paddy grains in water for three to four times

Soak the grains overnight in sufficient water and next day boil in a container for 15-20 min

Remove the excess water by spreading the boiled grains on sieve

Keep the grains under shade for 4 hours to get dry

Mix the grains with gypsum (calcium sulphate @ 2%) and chalk powder (calcium carbonate @ 0.5%) so that pH is maintained to around 7-7.8 and avoid the clumping

Fill around 300 gm of prepared substrate in glass bottles/PP bag with 2/3rd volume filled. Plus the bottles/PP bag with non-absorbent cotton and cover the plugs with aluminum foil

Autoclave substrate filled bottles/bag at 22 p.s.i pressure for 1.5-2 h

Leave the bottles /bag in the room for 24 h for cooling

Keep these bottles/bag in a laminar air flow chamber under UV light for 20-30 min before the inoculation

Inoculate a piece of pure culture growing mycelium from Petri plate/slant to these substrate bottles under aseptic conditions

Incubate in BOD incubator at 25°C for 8-12 days. Shake these bottles/bags gently after every 5 days

In around 2-3 weeks the mycelium fully colonize the spawn grains

Mother spawn is ready

Mother spawn is used to make commercial spawn which is prepared in polypropylene (PP) bags. That is, few grains of readymade spawn are added in each bag (It is not recommended to multiply spawn to spawn beyond two generations) . Polypropylene bags are used as these can be autoclaved and are cheap and easy to transport (normal plastic bags will melt). These are then incubated for 3 weeks. In between we inspect these bags, shake once or twice and remove bags that might have gone bad/ contaminated. These are then incubated for 3 weeks. In between we inspect these bags, shake once or twice and remove bags that might have gone bad/ contaminated.

Liquid spawn production technology

Materials required for liquid culture

- A nutrient rich liquid medium (Sterilized water with a nutrient added).
- A sterile mason jar with a lid that has a hole in the top.
- Micro pore tape (medical tape is a type of pressure-sensitive adhesive tape used in medicine and first aid to hold a bandage or other dressing onto a wound).
- Mushroom spores or mycelium.
- A sterile syringe or inoculation loop
- A magnetic stirrer can be a helpful tool when making liquid culture for mushroom cultivation. The stirrer helps to distribute the spores or mycelium evenly throughout the liquid medium and can also promote faster growth of the mycelium.
- A sterile scalpel (only necessary if using agar or a spore print).

A simple way of making a breathable lid for your mason jar:

A mason jar lid is taken, and a hole is drilled in the middle of it. This should be about 6 mm across. Then this hole is covered with 2 layers of micropore tape which acts as a filter and breathable hole for the mycelium. There are more sophisticated ways of doing this but is quick, easy, cheap and works well.

How to make a nutrient-rich liquid medium for your culture?

2-4 grams of sugar such as honey is put per 100 ml of distilled water and sterilization is done.

Ingredients:

Light malt extract (LME) or Malt extract agar (MEA): Provides carbohydrates and nutrients.

Sugar: A simple sugar for energy.

Yeast extract: Contains vitamins, minerals, and amino acids (optional)

Peptone: A source of nitrogen and amino acids (optional)

Water: Distilled or sterilized water to prevent contamination.

Steps:

Preparation of ingredients: The components are measured based on a recipe or a predetermined ratio. Typical ratios might include 2g LME, 1g dextrose, 0.1g yeast extract and 0.1g peptone per 100 ml of water.

Mixing of ingredients: The measured amounts of LME, dextrose, yeast extract and peptone is added to the distilled water. Stirring is done thoroughly to dissolve the components completely.

Magnetic stirrer: A magnetic stirrer may be used for proper and better stirring.

Sterilization: Once dissolved, the liquid medium is sterilized by autoclaving or pressure cooking at 15 psi (121°C) for around 15 minutes. If longer sterilization over 15 minutes is done, then there is a higher chance that the sugar will caramelise rendering the medium useless for mycelium cultivation.

Cooling and storage: After sterilization, the liquid medium must be cooled down to room temperature in a sterile environment, such as a laminar flow hood. Once cooled (takes around 4 hours), it's ready to use for inoculation.

Inoculation

Inoculation: For inoculation aseptic techniques are use to infuse the liquid medium with the desired mushroom culture. This can be done by transferring a small piece of mycelium or spores into the liquid medium using a sterile syringe or other sterile tools.

Incubation: the jar (using your breathable lid) must be sealed with the inoculated liquid medium and it is placed in a warm, dark place suitable for specific mushroom strain. Monitoring should be done for signs of growth (such as mycelium spreading through the liquid) over the coming days or weeks.

Mycelium Distribution: If a magnetic stirrer is used then the jar can be simply put on the stirrer plate and give it a whizz for a few seconds - minutes. Ideally this should be done once a day until the culture is ready. Otherwise, we will have to manually swirl the culture being careful not to get our lid wet.

Maintenance and storage:

Regular checks: Periodical checking of the liquid culture should be done for signs of contamination or unusual growth.

Storage: Storing of any unused liquid culture should be done in a refrigerated environment to prolong its viability. Proper storage procedures must be followed to maintain the culture's health.

We should remember that maintaining sterile conditions throughout these processes is crucial to prevent contamination and ensure successful growth of mushroom cultures. Working in a clean environment and sterilizing equipment are key in successfully cultivating mushroom liquid cultures. These cultures are used for mushroom cultivation.

Skill Set (PP) 4 : Cultivation technology and processing of oyster mushroom (*Pleurotus* sp.)

Skills to impart : To learn cultivation and processing techniques of oyster mushroom

The cultivation of oyster mushroom is undertaken by following methods:

1. Mushroom spawn.
2. Substrate preparation.
3. Spawning of substrate.
4. Crop management

1. Mushroom spawn:

Freshly prepared (20-30 days old) disease free, good quality spawn should be procured from a reliable and qualified distributor which will ensure robust yields and healthy mushrooms.

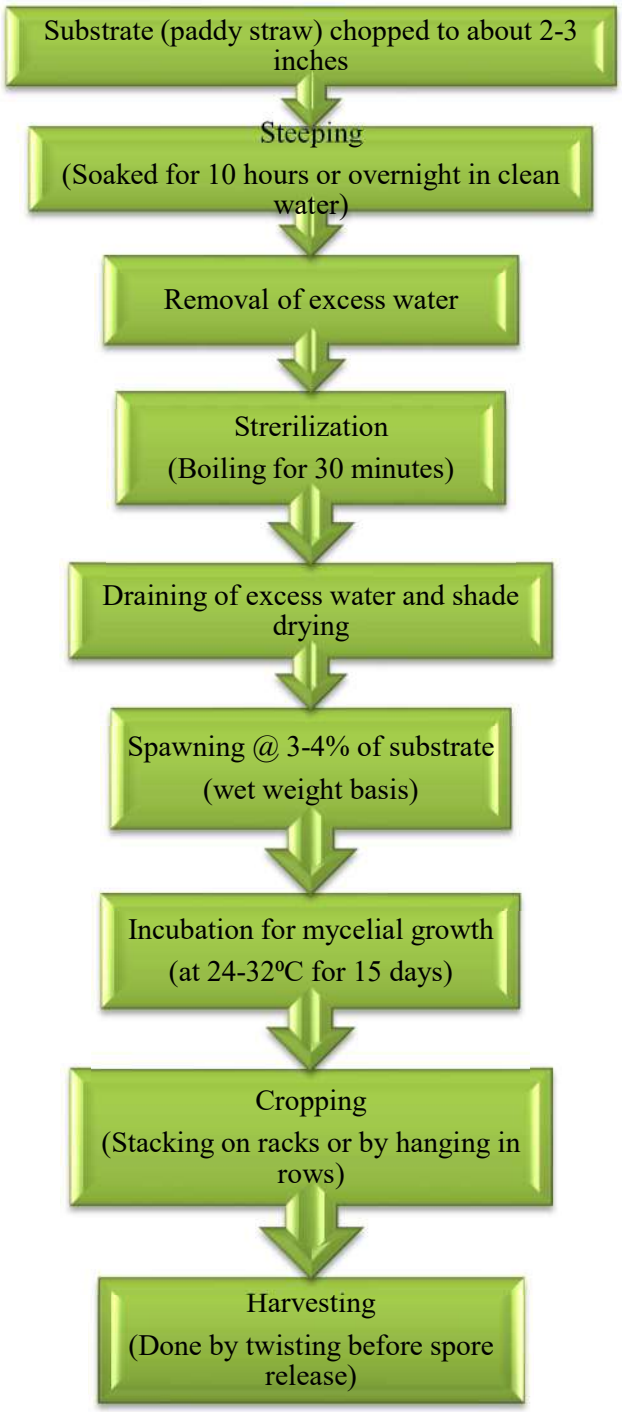
2. Substrate preparation:

a. Raw materials: Oyster mushroom can be cultivated on a large number of agro-wastes like paddy straw, wheat and ragi, stalk and leaves of maize, millets and cotton, used citronella leaf, sugarcane bagasse, saw dust, jute and cotton waste, dehulled corncobs etc.

b. Chopping of paddy straw: Fresh and healthy well dried paddy straw should be chopped to a length of 2-3 inches manually with a knife or with the help of chaff cutter.

c. Steeping: The chopped paddy straw is steeped in water for at least 10 hours or soaked overnight in clean water.

d. Sterilization: Excess water is drained from the soaked paddy straw and boil by soaking in water for 30 minutes. Water is drained out and the paddy straw is spread on a tarpaulin under shade condition and let it cool down and for removal of excess water.



3. Spawning of substrate:

For spawning, spawn of not more than 30 days old should be used for best result and good yield of mushroom. Prior to spawning room should be cleaned and fumigated with 2% formaldehyde to avoid contamination. PP bags (12 × 18 inches) should be sterilized with ethanol before spawning. Spawn @ 3-4% of substrate (wet weight basis) e.g., 150-200gm spawn per 5kg of substrate wet basis mixed in layers by filling the bag with 1/5 portion of the bag with the substrate and the layer of spawn uniformly covering the periphery and repeating the process for till fourth layer. Tie the

mouth after firmly pressing the bag with a rubber band. Holes are made in the bag after the spawning at 10 cm apart between rows and column.

4. **Crop management:**

   a. Incubation: The spawned bags are kept in incubation room for mycelial growth for 15 days at 24-32ºC. Spawn bags can be kept on a raised platform or shelves for mycelial colonization of the substrate. During mycelial growth no ventilation is needed, and water should not be sprayed as high humidity is not required at this stage. After 15 days when the mycelium has colonized the substrate and forms thick mycelial mat it is transferred to cropping room.

   b. Cropping: The bags are arranged on racks or hanged with plastic ropes. Proper management of temperature and humidity is required during this period. Frequent spraying of water is required depending upon the atmospheric humidity. Sufficient ventilation has to be provided during fruiting. Contaminated bags with mould may be discarded while bags with patchy mycelial growth may be left for few more days to complete the mycelial growth.

   c. Harvesting: The right shape for picking can be judged by the shape and size of the fruit body. The fruit bodies should be harvested before spore release, by twisting so that the stubs are not left on the beds.

Skill Set (PP) 5 : Cultivation technology and processing of milky mushroom (*Calocybe indica*)

Skills to impart : To learn cultivation and processing techniques of milky mushroom

Substrate and its preparation of Milky Mushroom (*Calocybe indica*):

The mushroom can be grown on a wide range of substrates. Substrates exposed to rain or harvested prematurely (green colour) are prone to various weed moulds, which may result in crop failure. It can be grown on straw of paddy/wheat/ragi/maize/bajra, cotton stalks and leaves, sugarcane bagasse, cotton and jute wastes, dehulled maize cobs, tea/coffee waste, etc., However, cereal straw (paddy/wheat), which are easily available in abundance are favoured.

Straw is chopped into small pieces (2-4 cm size) and soaked in fresh water for 8-16 hours. This period can be reduced when pasteurization is to be done by steam. Main purpose of soaking is to saturate the substrate with water. It is easier to soak if straw is first filled in gunny bag and dipped in water.

1. **Pasteurization/sterilization:** Pasteurization/sterilization can be achieved by any of the following ways.

   a. Hot water treatment: Water is boiled in wide mouth container and chopped wet straw filled in gunny bag is submersed in hot water for 40 minutes at 80-90°C to achieve pasteurization. This is very popular method particularly with small growers.

   b. Steam pasteurization: Wet straw is filled inside insulated room either in perforated shelves or in wooden trays. Steam is released from a boiler and the temperature inside substrate is raised to 65°C and maintained for 5-6 hours. Air inside the room should be circulated to have uniform temperature in the substrate.

c. **Steam sterilization:** Substrate is filled in polypropylene bags (35 cm × 45 cm, holding 23 kg wet substrate) and sterilized at 15 psi for 1 hour. Once pasteurization/sterilization is over straw is shifted to spawning room for cooling and spawning.

d. **Chemical sterilization technique**: Technique defined for oyster mushroom (straw soaked in solution having 75 ppm bavistin and 500 ppm formalin) can also be used. In South India many farmers are using this technique. However, in 5-10% of bags, spawn run may not be complete and *Coprinus* appears in such cases.

3. Spawning and spawn running of Milky Mushroom (*Calocybe indica*) :

Spawning methods are similar to that mentioned for oyster mushroom. However, layer spawning is most used in milky mushrooms. Higher spawn dose of 4-5% (wet wt. basis) is used. After spawning bags are shifted to spawn running room and kept in dark where temperature between 25-35°C with 80% RH is maintained. It takes about 20 days for the substrate to get colonised and after that bags are ready for casing.

4. Casing of Milky Mushroom (*Calocybe indica*) :

Casing means covering the top surface of fully colonised bags, with pasteurized casing material. Pond soil/soil (75%) + sand (25%), Coir pith + soil, FYM + soil can be used as casing material. However, soil (75%) + sand (25%) is generally preferred as casing material. Casing thickness is between 3-4 cm. Casing provides physical support, moisture and allows gases to escape from the substrate. Casing material, pH adjusted to 7.8-7.9 with chalk powder, is sterilized in autoclave at 15 p.s.i. for one hour or chemically treated with formaldehyde solution (2%) about a week in advance of casing. Treated casing is covered with polythene sheet to facilitate the action of formaldehyde and also to avoid its escape in the atmosphere. Soil is turned at an interval of 2 days so that at the time of casing, it is free from formalin fumes. For casing, bag's top is made uniform by ruffling top surface and spraying with carbendazim (0.1%) + formaldehyde (0.5%) solution.

Casing material is sprayed with the above chemicals to saturation level. Temperature 30-35°C and RH 80-90% are maintained thereafter for entire cropping cycle

5. Cropping of Milky Mushroom (*Calocybe indica*):

It takes about 10 days for mycelium to reach to top of the casing layer, thereafter fresh air is introduced and minimum 3-4 air changes per hour are required. Light should be provided for maximum duration during the entire cropping period. These changes in environment result in the initiation of fruiting bodies within 3-5 days. Mushrooms with 7-8 cm dia. are harvested by twisting, cleaned and packed in perforated polythene/polypropylene bags for marketing.

6. Crop management at different stages of Milky Mushroom (*Calocybe indica*):

a. **Substrate preparation:**

Substrate is a major source of weed, molds and disease-causing organisms. Hence substrate should be of good quality and is chopped and soaked at a distance from bag filling/spawn running and cropping area. The workers chopping straw should not be involved in bag filling and spawning.

b. **Bag filling, spawning and Spawn run:**

Bag filling and spawning area should be sprayed with formaldehyde (1%) twice a week. For large scale production, it is advisable to have hepa filtered air circulation in spawning area.

Spawn running area should be sprayed with formaldehyde 0.5% (5ml/ litre of water) and malathion 0.1% (1 ml/ litre of water) once a week.

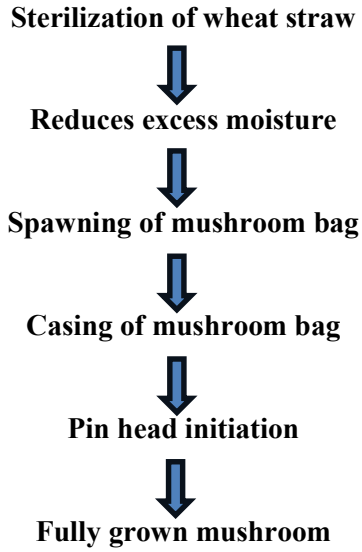
c. Casing and cropping:

Carbendazim (1 g) + formaldehyde (5ml) in 1 litre of water is sprayed before casing. Repeat spray on the casing soil and in the room again after a week. Malathion (0.1%) should further be sprayed on the next day of casing to protect the crop from flies.

The fungicides or insecticides should not be sprayed on mushrooms.

If any patch of mold is noticed, do spot treatment with formaldehyde (4%, 40 ml/litre) by soaking cotton in the solution applying itying on and around infected spots. Before removal of bags/ disposing of spent substrate, formaldehyde (2%) should be sprayed.

Flow Chart for Cultivation of Milky Mushroom



Water management:

This is very important for a good and healthy crop. During the rainy season, controlled watering is required, and watering once in a day may be enough. During winter watering twice may be sufficient. However, during summer as water loss is high, it becomes very difficult to maintain the requiredired RH and moisture of the substrate. During such period one should spread sand on floor (around 6" thick) and use mist sprayer 3-4 times and frequently check the moisture of the casing by touch. Watering should also be adjusted to maintain RH (80-85%) inside cropping room.

Skill Set (PP) 6 : Cultivation technology and processing of shiitake mushroom

Skills to impart : To learn about cultivation and processing of shiitake mushroom

The mushroom cultures or strains can be either collected from reputed mushroom research centre like Directorate of Mushroom Research (DMR), Solan (HP) or fruiting body can be collected directly from the forests and identified using the taxonomic keys and made into a pure culture. The pure cultures will be sub cultured and maintained for further use. By using suitable substrates, the mother spawn and the commercial spawn will be prepared by the below mentioned spawn production cycle.

Protocol for Spawn Production

Mushroom spawn can be prepared on any kind of cereal grains. The locally available grains such as paddy grains, wheat, jowar, bajra, sorghum will be used. Spawn substrate *i.e.* cereal grains should be free from diseases and should not be broken, old, or insect damaged. The grains will be thoroughly washed in sufficient water three to four times to remove soil debris, straw particles, *etc*. Washed grains will be then soaked in sufficient water for 20-30 minutes and boiled in a container for 20-25 minutes. Normally for soaking and boiling 20 kg of grains, 35 litres of water is required. Excess water from the boiled grains will be removed by spreading on a sieve made of fine wire mesh or muslin cloth.

The grains will be left as such for a few hours on the sieve so that the surface water will be evaporated. Then the grains will be mixed with 200 gm of Gypsum (Calcium sulfate) and 50 gm of chalk powder (Calcium carbonate) for 10 kg of grains (dry weight basis) so that the pH of the grains will be around 7 to 7.8 and they will not form clumps. First Gypsum and chalk powder will be separately mixed and then they will be thoroughly mixed with the grains. This mixing should be done on a smooth surface after wearing gloves. Using the polypropylene (PP) bags, the grains will be filled and plugged with non-absorbent cotton and tied with a rubber band. The bags will be then sterilized at 121^0C for 15 to 20 minutes. Autoclaved bags will be shaken well before inoculation so that the water droplets accumulated inside the bags will be absorbed by the grains. Ten to fifteen gm of grains from master spawn will be inoculated per PP bag. Then the bags will be kept in an incubation room at 25±2 ^{0}C for 12-15 days. Fully colonized bags will act as a mother spawn and will be multiplied for commercial spawn production and cultivation of shiitake mushrooms.

Cultivation of Wooden Logs

Shiitake Mushroom (*Lentinula edodes*) is the most significant culinary and medicinal mushroom which is only surpassed by button mushrooms in terms of global mushroom production. Prized for their flavor and texture, shiitake mushrooms are wonderful. It is used therapeutically to treat conditions like cancer, AIDS, environmental allergies, Candida infections, recurrent colds and flu, and disorders affecting weakened immune systems. Shiitake also helps lower chronically high cholesterol, regulate urine incontinence, and ease bronchial inflammation. As an immunomodulating agent, lentinan, a cell-wall component taken from the shiitake fruiting bodies, may be helpful as a general rejuvenator for elderly individuals as well as a preventative measure to shield young, healthy people who are physically active from overwork and tiredness.

Shiitake mushroom grows in cool temperatures (7-25°C) and require high relative humidity (75-85% RH), indirect sunlight, and fresh air. Currently, Shiitake is being extensively cultivated in different parts of North-east India such as Nagaland Meghalaya, and the mid-mountain ranges of Arunachal Pradesh and Manipur.

Cultivation technology on wooden logs

Wooden logs are mainly composed of polysaccharides, cellulose, hemicellulose, and lignin, which are all decomposed by shiitake mycelia and used as their energy source. Sugars play an important role in the initial mycelial growth. Logs have a relatively low amount of nutrients compared with other agricultural wastes. This low nutritional availability also makes logs unattractive to other microorganisms. The bark on a log also provides very efficient protection from the attacks of other fungi and molds and it also prohibits moisture evaporation from the log. The suitable tree species for shiitake mushroom cultivation are *Quercus* spp., *Lithocarpus* spp., and *Castanopsis* spp. which are generally available in North East India.

Spawn Production Cycle

1. Healthy and cleaned cereal grains

⇩

2. Boil Grains in water (20-25 min).

⇩

3.Remove excess water on sieve

⇩

4.Dry grains in shade (4 hrs.)

⇩

5.Mix $CaCO_3$ (50 gms) and $CaSO_4$ (200 gms) for 10 kg of grains

⇩

6.Fill in PP bags and place cotton in mouth of bags tie with rubber band

⇩

7.Sterilize in autoclave at 121 ^{0}C for 15 to 20 minutes

⇩

8.Inoculate growing mycelium of desired strain using laminar flow

⇩

9.Incubate in BOD at 25+2 ^{0}C for 12-15 days

⇩

10.Commercial spawn is ready

Protocol for Cultivation of Shiitake Mushroom on Wooden Logs

1. The logs with 10-20 cm diameter will be selected and cut into uniform length of 118 cm. The logs will be uniformly drilled with a diameter of 1.2 cm and depth of 3.5 to 4 cm depending on the diameter of logs with the help of drilling machine. The holes will be made at 10 to 15 cm (Diamond pattern of drilling).
2. The holes on the wooden logs will be filled by the spawn (4-6 grains per hole) followed by saw dust of same wood species used. Then holes will be sealed with wax to prevent loss of

moisture and contamination.

3. Inoculated logs will be arranged in places where suitable humidity, good drainage and indirect sunlight are available.
4. The optimal temperature for mycelial growth is 22-26 ^{0}C, while the wood-decay process is stronger at 25-30 ^{0}C. The optimal water content of logs during spawn run is around 35 % in wet base, which represents a 5-10 % loss from the weight of living fresh logs. In the dry season, watering is effective.
5. Inoculated logs will be re-stacked several times, and it takes 4 to 9 months to colonize in the log (called spawn run) according to the environmental requirements of each growing stage. Several stacking methods such as bulk stack, crib stack, lean-to stack, and A-frame stack have been recommended.
6. The main focus of log management should be on mycelial protection for one or two months after inoculation on pest and disease control during the spawn run period and on easy working during the pinning and fruiting periods.
7. A fully incubated shiitake mycelium is ready to change from the vegetative stage (mycelial growth) to the reproductive stage (fruiting). A sudden change of environment is required to trigger the reproductive stage. Lower temperature, higher humidity, and light are the key points of this environmental change.
8. The first step of the reproductive stage is primordia formation. A fruiting body primordium is a tiny mycelial mass, around 2-5 mm in diameter which is formed at the inner bark of logs.
9. Once primordia are formed, they should develop into fruiting bodies that are large enough to harvest. Fruit body development is stimulated by low temperatures from 5 to 20 depending on the strains and watering.
10. Log beating is a physical shock that is also known to be effective in fruiting induction. Many growers soak the logs in cold water at 15-20 minutes to promote fruiting body development. The soaking process gives logs water and physical shock.
11. The shiitake mushroom fruiting bodies will be harvested when they attain complete maturity using a sterile knife and stored in PP bags. Normally, it takes 7 to 10 months for the emergence of fruiting bodies.
12. Logs will usually give fruiting for 5-6 years without additional inoculation depending on the size of the log and conditions.

Skill Set (PP) 7: Hands-on-training practices on mass production of liquid bio-fertilizers

Skills to impart: To learn the production of liquid bio-fertilizer

Biofertilizers are referred to ‘organic fertilizers’ or ‘fertilizers containing organic matter’ these are opposite to inorganic fertilizers and they contain living microbes whose activity will influence the soil ecosystem. They also produce supplementary substances useful for the growth and development of plants. These fertilizers contain live and efficient formulations of bacteria, fungi or blue-green algae either separately or in combination that can fix atmospheric nitrogen, solubilize phosphorus and decomposes organic matter or oxidizing sulphur. They are found in either liquid or solid forms. However, it has been said that solid bio fertilizers have shorter shelf-life hence the use of liquid

fertilizers are encouraging these days. Liquid bio fertilizers are eco-friendly, cost-effective consortium of microbes provided with suitable liquid medium to keep up their viability for certain periods which aids in enhancing biological activity of targeted sites. They have cell protectants or chemicals that promote resting spores and cysts for longer shelf life and tolerance to adverse conditions.

Importance liquid biofertilizers:

Challenges encountered in solid carrier biofertilizers that they have lower shelf life of microbes i.e. up to six months, with initial population density of 10^8 cfu/ml, non-tolerance to UV rays and temperature of more than 30 ^{O}C. However, liquid bio fertilizers have an average shelf-life of two years with a constant population count of 10^9 cfu/ml and can be tolerant to higher temperatures up to 55 ^{O}C as well as for UV radiations. They must be stored at 10 ^{O}C temperatures. To extend the shelf life of liquid inoculants addition of sucrose, glycerol, NaH2PO4, and (NH4)2 PO4 must be done. These all can protect the cell suspension against thermal shocks, and pH variations as well as improve the applicability and performance of formulated liquid in the field. They can also counteract the adverse effects of inorganic fertilizers.

Functions of liquid biofertilizers:

These fertilizers act on rhizospheric zones in plants or the interior of plants and also contribute to plant growth by modulating the effects of environmental stress both biotic and abiotic. They also increase soil organic carbon, microbial biomass carbon, moisture retention capacity, nitrogenase activity in roots or in rhizosphere thereby reinstating the agro-ecosystem which was getting exhausted and degraded due to agronomic activities associated with conventional farming.

Application of liquid bio-fertilizers:

Application of 1ml of liquid bio fertilizers is equal to the application of 1kg of carrier bio fertilizer and their dosage is 10 times lesser than other traditional biofertilizers.

1. Seed application must be done by mixing this solution with 100% jaggery solution. Spread the slurry over the seeds, mix them and spread the seeds on the floor in shaded area. Dry them overnight and then use these seeds for sowing in the field.
2. Root application is done in seedling stage by dipping roots for half an hour. For this in an acre the inoculation solution of 2 to 2.5 lit. must be used.
3. Soil application is done at the time of planting of crops, 20ml of liquid biofertilizers must be mixed in compost and incubated with well decomposed granulated FYM for 24 hrs.

Materials required:

Pure culture, Petri plates, conical flasks, measuring cylinders, Nutrient broth, Inoculation loop, Cotton, Laminar airflow, Autoclave, Weighing balance, Fermenters/Bioreactors, Adjuvants, Colony counter, Bottles, Refrigerator *etc.*

PROCEDURE:

- Sterilization of Lab scale fermenter
- Preparation of biofertilizer mother culture
- Multiplication of mother culture using lab scale fermenter
- Sterilization of Seed fermenter
- Multiplication of bio-formulation culture in Seed fermenter

- Sterilization of production fermenter
- Mass production of liquid bio-fertilizer/bio-pesticides using large scale production fermenter
- Cleaning of fermenters
- Bottling, capping, labeling, storage, quality control

Skill Set (PP) 8: Phanerogamic plant parasites on their host

Skills to impart: To learn different phanerogamic plant parasites and their host

Plantae kingdom is divided into two sub-kingdoms *viz*., Phanerogams and cryptogams. Phanerogams are flowering plants that produce seeds, while cryptogams are plants that reproduce by spores and do not produce any seed or flower. In the world of plant parasites that can make their food but still feed on other plants is an important part of plant science. (Smith & Stevens, 2021). Phanerogamic parasites are flowering plants that lead a parasitic life on other living plants. They produce flowers and seeds and parasitize a great number of economic plants causing considerable loss in yield. They parasitize by invading the stem or root of the host plants by a specialized structure called haustoria. Some of these parasites possess chlorophyll, which manufactures carbohydrates to a limited extent and depend on the host for minerals, salts and water. These are generally called semi or partial parasites. Some of the parasites, which do not have chlorophyll, depend entirely on the host plants for their food materials. They are called holo or total parasites.

CLASSIFICATION:

Phanerogamic plant parasites/ pathogenic flowering plants also called parasitic angiosperms are classified into two groups:

A. Stem parasites: These parasites attack the stem of the host plant and get their nourishment. There are two types.

i. Total or holo stem parasites: These phanerogamic parasites are devoid of chlorophyll and remain entirely dependent on host plant for their existence. Ex. Dodder or Amarbel (*Cuscuta spp.*)
ii. Partial or semi stem parasites: These phanerogamic parasites have chlorophyll and can synthesize their food in the prsunlight sun light. But depends on the host plant for minerals and water. Ex. Banda (*Loranthus spp*.)

B. Root parasites: These parasites attack on roots of the host plant and get their nourishment. There are two types.

i. Total or holo root parasites: These phanerogamic parasites are devoid of chlorophyll and remain entirely dependent on the host plant for their existence. Ex. Broomrapes (*Orobanche* spp.)
ii. Partial or semi-root parasites: These phanerogamic parasites have chlorophyll and can synthesize their food in the presence of sunlight. But depends on the host plant for minerals and water. Ex. Witch weed (*Striga* spp.)

Important Genera of Phanerogamic Plant Parasites:

Currently, there are 277 genera and 4100 parasitic plant species reported so far. Out of it, only 25 genera are recognized as plant pathogens. Among the 25 genera, four are more damaging to crops *viz.,* Striga (witchweed), Orobanche (broomrape), Cuscuta (dodder), and Arceuthobium (dwarf mistletoe). Striga is more prevalent in Asia and Africa, while Orobanche is worldwide, but more damaging in the Middle East. Both Striga and Orobanche produce microscopic seeds called dust seeds that persist in the soil for a long time and are difficult to control. Dwarf mistletoes (*Arceuthobium spp.*) are the major pathogens of coniferous trees (belonging to families *Pinaceae and Cupressaceae*). Dendrophthoe (*Loranthus*) and *Viscum* species are parasitic on the forest, fruit, and avenue trees and are responsible for their dieback and drying in Himachal Pradesh.

I. Striga (Witchweed):

Striga is an obligate root hemiparasite, although the seedlings above ground do form chlorophyll. It has made a greater impact than any other parasitic angiosperm. Among the species, two species *viz., S. asiatica* and *S. hermonthica* cause maximum damage attacking important crops like maize, sorghum, pearl millet, rice, sugarcane and legumes. During their life cycle, produces thousands of dust seeds which is disseminated by wind and rain. The chemical signals exuded by the host enable the striga seeds to detect the type of host and its distance. Seed germination of Striga is cryptocotyler *i.e.,* the cotyledons remain within the seed when the radical comes out. The root hairlike structures produce radical glue into the host. In the host suitable, a haustorium is formed that penetrates and forms a link with the host vascular system. Once the parasite is established, the distinctive seedling of Striga is formed underground, which lacks chlorophyll, possesses scale-like leaves, and produces abundant adventitious roots that form additional haustoria, establishing more connections with the host. The seedlings exert great influence on the growth-regulating metabolism of the host, stimulating root production. Significant damage to the host occurs at this stage. The next stage is the emergence of the seedlings above ground. Chlorophyll develops, and in due course, flowers and seeds are formed. The life cycle is ready for a repeat.

II. Orobanche (Broomrape):

It is an obligate root holoparasite, infecting legumes, solanaceous crops, carrots, cabbage, cauliflower, lettuce, and sunflower. The parasite appears as whitish, yellowish, or brownish stems, about 30 cm high that arise from the roots of the infected host and bear beautiful flowers. Besides bracket-like leaves lacking chlorophyll. Total crop failure may be observed in heavily infested soils. They required a temperature of 10-20 ℃ for seed germination and are considered as colder climate parasites. During winter, attacks tobacco plant but fails to infect sunflowers during summer in the same field. The germinated seeds of Orobanche are geotropically neutral *i.e.,* they do not grow downward in the soil.

III. Cuscuta (Dodder)

It is an obligate stem holoparasite and is among the best-known of all parasitic plants. Its slender, twining, orange-yellow, leafless stems form a conspicuous tangled mass on the host. The host range is large, though monocots are less preferred. Dodders are the most important parasites of legumes. Among the species, *Cuscuta campestris* is the most widely distributed and attack crop. It causes considerable damage to alfalfa, flax, sugar beet, onion, and other crops besides fruit, fodder, and forest trees and shrubs. It also transmits viruses.

IV. Mistletoes:

Mistletoes are stem holoparasites occurring in three families under the order Santalales. The three Families *viz* Loranthaceae: Showy mistletoes [*Loranthus* (Dendrophthoe)]; Santalaceae: sandalwood (*Pyrularia, Santalum*) and Viscaceae: Dwarf mistletoe (*Arceuthobium*), leafy mistletoe (*Viscum*). The showy mistletoes produce large and beautiful flowers that are pollinated by birds. The co-evolution of these parasites and the birds is also suggested by the seed dispersal mechanism operating in the birds. Santalaceae, the sandalwood family has a few members (*Pyrularia*, etc.) that hurt their hosts. Family Viscaceae is called the Christmas mistletoe family because their shoots with white berries are used as door festoons during Christmas in temperate countries. The family has seven genera, and a large number (543) of species, most of which belong to three genera, *Viscum*, *Phoradendron*, and *Arceuthobium*. The seeds are covered with a sticky substance, called viscin‘ that glues the seeds to the host surface.

Host

The highly variable host range of phanerogamic parasites is reflecting the diverse strategies to exploit their host plants. While some parasites exhibit a broad host range, capable of infecting numerous plant species across different families, others are remarkably host-specific, targeting only a select few closely related hosts. This variation in host specificity has significant implications for both the ecology of the parasites and the dynamics of the ecosystems they inhabit (Miller and Press, 2018).

A broad host range Parasites often possess adaptations that enable them to infect a wide variety of hosts by producing haustorial structures capable of penetrating diverse host tissues, as well as mechanisms to overcome host defenses and establish successful infections. While host-specific parasites exhibit a more specialized relationship with their hosts, often co-evolving alongside them to exploit specific ecological niches. These parasites may have evolved highly specific molecular interactions with their hosts, allowing for precise recognition and manipulation of host physiological processes.

Parasite	**Example**	**Common name**	**Host**
I. Stem parasite:			
Total parasite	*Cuscutta*	Dodder, gold thread, hellvine, hair weed, Devils hair, love vine	Alfalfa, clover, flax, potato
Partial (Semi) parasite (Hemi-parasite)	*Dendrophthoe*	Giant Mistletoe, Banda, Loranthus	Mango, Citrus, Rubber, Apple, guava
II. Root Parasite:			
Total (holo)/ complete parasite	Orobanche	Broom rape, Tokra	Tobacco, Tomato, Brinjal, Cauliflower
Partial (Semi) parasite (Hemi-parasite)	*Striga*	Witch weed, Striga	Sorghum, Maize, Sugarcane.

Skill Set (PP) 9: Production of bioagents (*Trichoderma*)

Objective- To develop and produce high-quality *Trichoderma* bio-agents that effectively enhance plant health, suppress soil-borne pathogens, and promote sustainable agricultural practices.

Procedure

Task 1: Soil Sample Collection, Preparation of PDA Media and Serial dilution technique

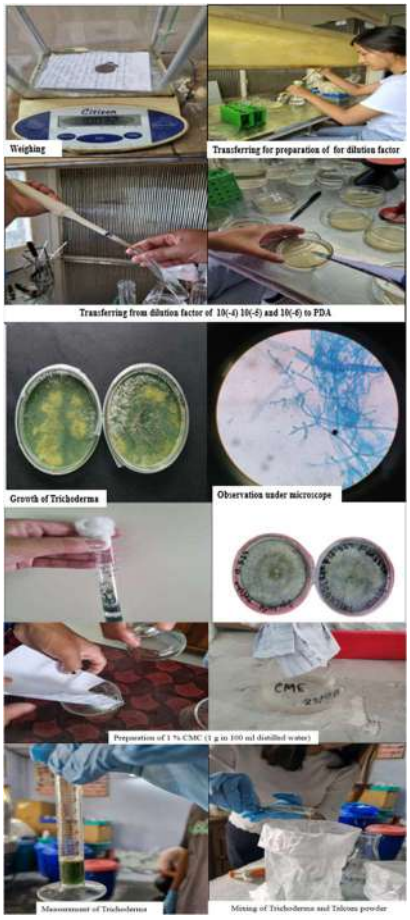
Activity-1: Collection of Soil samples from crop rhizosphere. The soil sample collected should be virgin and from the rhizosphere region of about 5-15 cm depth.

Activity-2: Preparation of Media.

-Weighing of PDA
-Addition of PDA in distilled water
-Sealing with cotton plug and wrapping with paper.
-Sterilization

Activity-3: Serial dilution of soil sample for isolating *Trichoderma.*

- Weighing of 1g of soil sample and place into a test tube containing 9ml of sterile distilled water.
- Transfer of 1ml of sample and transfer to the first test tube to make the total volume of 10 ml. It provides an initial dilution of 10^{-1}.
- Transfer 1 ml of the mixture sample from the 10^{-1} dilution to the second tube by using a pipette. The 2nd tube now has a total dilution factor of 10^{-2} and continues till 10^{-7}
- Drawing of 1 ml of sample from the diluted samples of 10^{-4} 10^{-5} and 10^{-6} and poured in PDA media to check the growth of *Trichoderma*
- Selection of dilution factor showing *Trichoderma* growth without contamination and single colony is used for subculturing.
- A single colony form the inoculum is then transferred to the Petri plates using an inoculating loop
- The Petri plates are then sealed with a parafilm and incubated in the BOD at 24 ± 1^0C.



Activity 4: Mass Multiplication:

A. Preparation of adjuvants:

- Mixing of mannitol and CMC @ 1 g /100 ml of water to make 1 % Mannitol and 1 *% CMC respectively.

B. Talcum Based *Trichoderma*

- Mixing of *Trichoderma* with talcum powder in the ratio of 1:2 i.e., followed by addition of carboxy methyl cellulose (CMC) @ 5 g / kg the product.

C. Plate count technique

- Serial dilution of product is done followed by Plating, counting of colonies after 2-3 days and calculation of CFU by following the formula, CFU/ml– (Number of colonies*dilution factor) / volume of culture plate.
- Fresh product should contain not less than 28 x 106 cfu/g.

D. Mass multiplication *Trichogramma*

Activity-1: Steps involved in mass production

- Crushed maize/rice/ wheat grains should be heated at 100C for 30min
- Mixed with 0.1% Formalin solution and dry it with a fan
- Mix 20,000 nos. of *Corcyra* eggs with 2.5kg of the crushed grain and should be keep for 30days in wooden box
- After emergence moth should be transferred to net cage for oviposition
- Collecting eggs should be spread on a card and sterilized it with UV radiation
- Fix the trichocard in the crop field according to the requirement

Skill Set (PP) 10: Entrepreneurship development through mushroom production

Objective- To establish a sustainable and scalable mushroom production system that enhances food security, generates employment opportunities, and promotes eco-friendly agricultural practices

Task 1: Mushroom Farm site

Site selection by keeping in mind the distance of market, availability of good quality substrate, transportation etc.

Task 2: Constructions of low-cost polyhouse

Task 3: Substrate preparation

- Collection of good quality straw.
- Chopping of straw into 3-5 cm pieces.
- Soaking in fresh water for 6 -8 hours followed by boiling to kill competing microorganisms.
- Draining of excess water and sieve dried up to 60–70 % moisture and its determination manually by taking handful of straw and squeezing. Water should not drip but be wet enough to dampen the palm.

Task 4: Spawning

- Spawning is done in layer spawning. Holes are made in the bags to ensure better aeration and also to drain out excess water.
- After that Spawned bags should be stacked in racks in a neat and clean place i.e. spawn running room. Temperature of 28 ± 10C and humidity of 80 - 90 % should be maintained.

Task 5: Cropping and Harvesting

- After 20–22 days, when bags are fully impregnated with white mycelium, the bags are transferred into the cropping room.
- An ideal temperature for oyster mushroom growth is at a temperature range of 20 – 30°C.
- Relative humidity is maintained by spraying water twice a day on the walls and floor of the room.
- Once pinheads are 2–3 cm big, a little heavier watering is to be done on the blocks and further watering of blocks is to be stopped to allow them to grow.
- Mushrooms should be plucked before they shed spores to maintain quality.
- After 1st flush of harvest, the 0.5 to 1 cm outer layer of the block should be scrapped. This helps to initiate 2nd flush which appears after about 10 days.

HORTICULTURE

FRUIT SCIENCE

Skill Set (FSC) 1: Propagation of dragon fruit (*Hylocereus undatus*)

Skills to impart: Vegetative propagation of dragon fruit through stem cuttings

Tools and materials: Secateur, Trowel, Polybag, Rootex, Fungicide, Potting media (Soil, FYM or Vermicompost)

Procedure

A. Selection of mother plant for making cuttings

- Select 2-3 years old strong and dark green healthy branches free from pest and disease attack during the spring season
- Select the upright stem segment of 30-40 cm length protruding out from the primary stem
- Make sure the cutting has good eyes with strong thorns
- Cut off the end using secateur to create more surface area along the tender part of the plant as new roots don't grow well from the woody part.

B. Treatment of cuttings

The cut end portion should be dipped in Rootex to induce rooting and sprayed with Bavistin @ 0.05 % to prevent a fungal attack.

C. Raising nursery

- For the raising of cuttings, the cut stem should be planted in a nursery bed at a spacing of 8 to 10 cm or in a pot of potting media using a mixture of topsoil: FYM or Vermicompost of 1:1 ratio
- Fill up the soil using a trowel in the pot/ polypack and place the cutting 2 to 3 inches deep in the soil/pot. Compress the soil slightly to keep the cutting upright.
- Place the cuttings in a partial shade or inside polyhouse

Precautions

- Watering of the cuttings should be done at 2 days interval or three times in a week depending on the soil dryness.
- Rooting is indicated by emergence of new growth in the tip portion of the stem which occurs within 1 month after cutting
- Transplanting of cuttings to main field can be done during May to June

Management of diseases

Stem rot

- Yellowing of stem above the soil surface followed by rotting.
- Drenching with Blitox @ 0.5-1% or Blue Bordo.

Anthracnose

Spraying with Mancozeb@2%

Skill Set (FSC) 2: Propagation of guava (*Psidium guajava*)

Skills to impart: Propagation of guava through air layering method

Tools and materials: Knife, sphagnum moss or coco peat, rooting hormone, polyethylene film, thread

Procedure

A. Selection of branches or shoots

- Guava shoot from previous year's growth of 1 cm in diameter is selected for air layering

B. Preparation of layers and covering

- A ring of bark about 3 cm long is removed or scraped off using knife
- The exposed area is covered with wet sphagnum moss or coco peat mixed with rooting hormone powder and tied with transparent polyethylene film with a thread on both ends
- Rooting takes place in about 30-40 days

C. Detaching of air layered shoots

- Cut the branches just beneath the layered portion after root formation occurs visible for outside.

Place it in a polybag filled with soil: FYM: sand of 2:2:1 ratio. Irrigate to maintain soil moisture.

Skill Set (FSC) 3: Propagation of Sikkim mandarin (Wedge grafting)

Skills to impart: Vegetative Propagation of Sikkim Mandarin through Wedge grafting

Tools and materials: Grafting knife, secateurs, grafting tape, scion & rootstock

Rootstock: Rough lemon (*Citrus jambhiri*)

Season of propagation: April to August

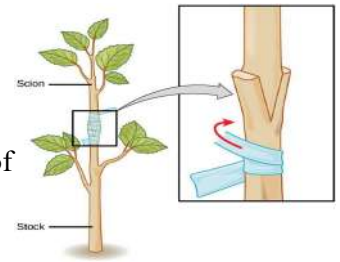
Ideal climate: 20-25^{o}C

Raising of rootstock:

- Seeds of Rough lemon are collected and shown during December to February which is immediately after extraction from fruit to avoid desiccation.
- Seeds should be treated before sowing to avoid phytophthora infection. One year seedling of rough lemon can be utilized as rootstock while grafting.

Scion material:

- Scion should be collected from healthy and superior mother plants. Selected mother plants should have attained maximum production age of 10 years or more.



Steps involved in wedge grafting

- The terminal portion of the stock plant is removed with a horizontal cut.
- V shape incision of about 5 cm in length is prepared or stock is split vertically on the stub of the plant.
- Shallow and downward matching incision is repaired on the lower portion of scion.
- Scion is inserted into the stock, with care to align cambia.
- Stock and scion are tied together with plastic strip or a grafting tape and waxed properly
- Scion and upper portion of stock are bagged to maintain high humidity and grown under shade to avoid overheating.

Skill Set (FSC) 4: Propagation of Sikkim mandarin (T-budding)

Skills to impart: Vegetative Propagation of Sikkim Mandarin through T-budding

Tools and materials: Budding knife, secateurs, budding tape, scion & rootstock

Rootstock: Rough lemon (*Citrus jambhiri*)

Season of propagation*:* April to August

Ideal climate: 20-25^{o}C

Raising of rootstock

- Seeds of Rough lemon are collected and shown from December to February which is immediately after extraction from fruit to avoid dessication.
- Seeds should be treated before sowing to avoid phytophthora infection. A year seedling of rough lemon can be utilized as rootstock while grafting.

Scion material

- Scion should be collected from healthy and superior mother plants.
- Selected mother plants should have attained a maximum production age of 10 years or more).

Steps involved in T Budding

- Choose a stock plant that is actively growing (to ensure that the bark will be slipping) and locate a straight section of stem in an intermodal region at a height of 15 to 25 cm above the soil line.
- The diameter of the stock should be approx. 7 to 10 mm (pencil thick, at least) at the point of bud insertion.
- Give a vertical cut through the bark to a length of about 2.5-3.75cm. At the top of this vertical cut, give another horizontal cut (1cm) in such a way that the two cuts given resemble the letter T.
- Lift the bark piece on either side of the vertical cut for the insertion of the bud.
- Select a required bud stick and start a slicing cut about 1.5cm below the bud and continue it upward and under the bud to about 2.5cm above the bud. Give another horizontal cut about 1cm above the bud.
- Remove the shield of bark containing bud. The traces of wood, if attached may be removed.

- Insert the bud between the flaps of bark on the stock with the help of budding knife in such a way that the horizontal cut of the shield matches the horizontal cut on the stock.
- Wrap the bud stick tightly with polythene strip exposing only the bud.
- After successful union rootstock is cut back to promote bud growth.

Skill Set (FSC) 5 : Propagation of litchi (*Litchi sinensis)*

Skill Set **:** Air layering

Tools and materials: Rooting media, sharp knife, Jute threads, Polythene sheet, Rooting hormone (IBA)

Ideal season: June-July

Ideal age of the plants: 5-6 months vegetatively propagated plants

Procedure

Step 1: Selection of shoot

- One year old branch is selected which are non-flowering, straight, healthy and vigorous. The selected shoot should have pencil size thickness and it should contain an enough amount (35-40) of leaves.

Step 2: Girdling

- The selected portion for girdling should be cleaned by removing the leaves from that region. The bark of 4-5 cm should be pulled out carefully without damaging the other shoot portion. After girdling the cambium portion should be scrapped gently with the knife for better success.

Step 3: Application of rooting hormone

- The IBA @1000-2000 ppm can be applied by making a powder with chalk powder and smeared on the girdled branch. The maximum area of apical region of the girdled portion should be covered with rooting hormone.

Step 4: Application of rooting media

- The girdled area is then wrapped around with one or two handful of mud pudding that is prepared by mixing well rotten cow dung, soil and sand in the ratio of 2:1:1 respectively. If the sphagnum moss is available, will serve a better rooting medium for air layering.

Step 5: Wrapping with polythene sheet

- It is covered with thin transparent polythene and tied at the both ends with the help of jute threads to preserve moisture.

Step 6: Cutting of rooted shoot

- The appearance of roots through the rooting media after 45 days, confirms the success of the air-layered shoots. Then plastic sleeve is removed. The rooted stem is cut just below the rooted section from the mother plant

Step 7: Transplanting the layered branch

The layered branch is transplanted in a poly bag as a new sapling.

Skill Set (FSC) 6: Propagation of banana

Skills to impart: Propagation of Bananas through macro propagation

Tools and materials: Sword sucker of banana, Sharp knife, Media, Shade house

Procedure

- Mother plant of desired variety is selected which is free from any disease more particularly bunchy top.
- Sword sucker of about three-month-old with a stout base should be selected.
- Sword sucker is removed with their rhizome from the mother plant and then it is decapitated with a sharp knife at the base and the leaf sheath attached to the rhizome are removed carefully so that eye buds in the rhizome are not disturbed.
- Then rhizomes are surface sterilized with fungicide solutions.
- Splitted or decortication of corm is done.
- After that it is placed in the media (Rice hull, Sawdust, Cocopeat, Vermicompost as media) for sprouting under shade.
- This method results in production of 9-15 uniform shoots/plants in a short span of time, roughly within 1- 3 months.

Skill Set (FSC) 7 : Preparation of plant growth regulator (PGR) and derivation of formulating PGR with desired strength

Skills to impart : Preparation of plant growth regulators

Tools and materials : Plant growth regulators (IBA, NAA, GA_3, etc.) and solvent (acetone, ethanol)

Procedure

Step 1: Selection of Plant growth regulators (PGR)

- Based on the requirements like initiation rooting of cutting, fruit drop control etc. the application plant growth regulators *viz*. auxin, cytokinin, gibberellins, ethrel etc. are selected.

Step 2: Selection of solvent

- The selected PGR should be mixed with the solvent and make up the volume as required. A suitable solvent should be selected that can dissolve the PGRs. For example, auxin hormone *viz*.,

NAA is soluble only in 1N NaOH (sodium hydroxide) and other plant growth regulators are soluble in acetone or ethanol.

Step 3: Preparation of desired PGR strength

- Using the following formulae, the required strength of the plant growth regulators are prepared. Weight the required PGR in analytical weighing machine and dissolved in suitable solvent then make up the required volume.

$V_1N_1 = V_2N_2$,

Where V_1 = Initial Volume (ml) of the substance

N_1= Initial Strength of the substance;

V_2= Final Volume of the substance

N_2= Final strength of the substance

Step 4: Application of PGR in horticultural crops

- The prepared PGR can be applied as foliar spray or seed treatment like fruit drop control measure using NAA, 2,4-D etc. and GA_3 hormone for the treatment of seed soaking for breaking seed dormancy at required recommended dose. Foliar spray should be done in morning or in the evening hour.
- Required concentration should be weighed accurately. If not, PGR like 2,4-D and 2,4,5-T act as broadleaf weedicide in higher concentration which will affect the plant. For example for control of fruit drop in Khasi mandarin, 2,4-D @ 15 ppm is effective. Overdose application above RDF should be avoided which will be harmful to the plant.

Skill Set (FSC) 8: Ethylene treatment for banana ripening

Skills to impart: Preparation of ethylene solution and technique to ripen banana

Tools and materials: Ethrel, NaOH pellets, Blotting paper, Cotton cloth, Wide mouthed vessel

Procedure:

Dipping treatment

- Harvest unripe mature fruits
- Prepare 0.1 percent ethrel solution (1 ml of ethrel solution in 1 litre of water)
- Dipping unripe bananas and wiping it dry
- Fruits are then spread over a blotting paper without touching each other and a thin cotton cloth is covered over this.
- The fruits will ripen within two days.

Keeping ethrel inside a wide-mouthed vessel:

- Take a wide-mouthed vessel
- 10 ml of ethrel and 2 gm of sodium hydroxide pellets are mixed in five litres of water taken in the vessel.
- This vessel is placed inside the ripening chamber near the fruits and the room is sealed air tight.
- About a third of the room is filled with fruits leaving the remaining area for air circulation.
- Ripening of fruits takes place in about 12 to 24 hours.

Advantages of using ethylene:

- Ethylene being a natural hormone does not pose any health hazard for consumers
- It is a de-greening agent, which can turn the peel from green to perfect yellow (in the case of bananas)
- It maintains the sweetness and aroma of the fruit, thus value addition in the fruit is possible as it looks more appealing

Skill Set (FSC) 9: Different propagating methods and techniques

Skills to impart: To impart the knowledge of different propating methods such as grafting, budding, cutting and layering

A. Grafting in fruit crops

Activity-1: To know about the different types of grafting techniques:

Grafting is a technique of propagation in which scion stick (shoot containing more than one bud) and rootstock are connected in a manner so that they may unite and subsequently grow and develop as a successful plant. There are different types of grafting techniques such as, Veneer grafting, Whip, Tongue, Cleft, wedge, Bridge, Epicotyl, Softwood grafting, Inarching and Top working.

Wedge grafting:

- V- wedge shape incision of about 5 cm in length is prepared on the stub of the plant.
- Shallow and downward matching incision is prepared on the lower portion of scion.
- The scion is inserted in rootstock firmly.
- The incised portion of rootstock is waxed properly.

Wedge grafting in Mango

Activity-2: To study about the Soft wood grafting as an example.

- This technique is commonly practiced in tropical and sub-tropical fruit crops.
- It is having high success rate. The process of grafting is done during rainy season when new growth appears on rootstock.
- Scion shoot of 10-15 cm length, 3-5 months old and pencil thickness girth will be selected.
- At 15- 20 cm height from ground level, the rootstock is beheaded.
- A vertical slit of 2.5 to 4.0 cm length is given on rootstock. On scion shoot, similar matching cut is prepared on slanting manner on both the surfaces in lower portion.
- It is inserted on insertion on rootstock and wrapped using polythene tape. In about 3 to 4 weeks, sprouting starts and graft starts growing.

B. Budding in mandarin

Activity-1: To know about the different types of Budding

- The process of connecting scion, which is a bud, and rootstock in a manner such that they may unite and grow successfully as one plant.
- There are different types of budding like, Shield budding, Patch, Chip, Ring, Modified ring and forkert budding.

Activity-2: To know about 'T' or Shield budding

- A boat shaped bud of 2.5 to 3.0 cm length is used for budding which is inserted in a rootstock at 15 to 25 cm height.
- If the bud is inserted by making vertical incision on rootstock, it is termed as shield budding.

T budding

- If 'T' shaped incision is made to insert the bud, it is 'T' budding.
- After inserting the bud in the incision on the rootstock, it is wrapped air-tightly using 300 guagepolyhtene tapes leaving the bud exposed.
- Shield budding is successful in plants having thin skinned shoots.

C. Propagation through layering

Activity 1: To study about layering techniques

- In this propagation technique, we will force to produce adventitious roots to a branch while it is still attached to the mother plant. Different types of layering techniques like, Simple layering, Serpentine, Mound, Trench, Tip and Air layering.

Air layering in litchi

Activity 2: To know about air layering.

- One year old or previous season shoot of pencil thickness is selected.
- About 5- 7 cm away from the base of selected shoot, a girdle of 2.5 to 3.0 cm size, by removing the bark.
- The girdled portion of the shoot is scrapped using gunny bag or with rear side of the blade.
- The gridled portion is then covered with moist sphagnum moss or coco-peat. The girdled portion is now using transparent polythene tape.

D. Propagation through cuttings

Activity-1: Preparation of different types of cuttings

- Separation of a portion from the mother plant and planted in a suitable planting media, so that it may constitute a new plant successfully is termed as cutting. There are different types of cuttings such as Stem cuttings, root cuttings and leaf cuttings.

Planting of Acalypha cuttings.

Activity 2: Preparation of semi-hard wood stem cuttings.

- In this type of cutting, 4 to 9 months old shoot of semi-hard nature is used for raising new plants.
- Shoots of 10 to 15 cm length are used for season preparing cuttings.
- Practiced during rainy to prevent drying of cuttings due to high humidity.
- Cuttings should be treated with 1000 to 1500 ppm IBA for better root initiation.

Skill Set (FSC) 10: Nursery production techniques in fruit and plantation crops

Skill to impart: Nursery rising technique in fruit and plantation crops

Tools and materials required: Khurpi, Polybag, media, fungicide, seeds

Procedure:

1. Preparation of soil media
   - Media should be mixed of Soil: Sand: FYM@ 1:1:2
   - Prepared soil media should be mixed with fungicide @1g/kg of it

2. Seed treatments
   - Seeds should be soaked in fungicide viz. Captan or Thiram 2g/liter of water and kept overnight
   - Seeds should be drained out and sowing should be done at 3-5 cm depth in the soil-filled polybag
   - If the seeds are recalcitrant type like mango, citrus, arecanut, coffee etc. then it should be sown within 1 week of fresh extraction for better germination

3. Stratification technique
   - If the seeds are temperate fruit crops like apple then chilling temperature of 4-7°C in moist sand should be treated for 30-45 days to break the dormancy of seed

4. Scarification technique
   - If the seeds are covered by hard seed coats like peach, plum etc then it should be scratch by sandpaper or GA3 treatment for early and better sprouting of the seed

Precaution:
- Light and frequent irrigation should be given to the seed sown polybag and excess irrigation should be avoided which will cause damping off/root rot disease

Skill Set (FSC) 11: Skill set on training and pruning in different fruit crops

Skill to impart: Training and pruning in different fruit crops

Tools and materials required: Secateurs, pruning knife

Procedure:
Training
- Based on the requirement of the fruit crops, training system like central leader system, open leader system and modified leader system are adopted
- Central leader system are generally followed in snow fall area to avoid accumulation of snow in the middle of tree canopy
- Open leader system are generally followed in fruit crops like guava, peach and plum which produce many new shoots
- Modified central leader system of training system is adopted in most of the fruit crops
- In all the training system, only single stem is maintained and all the water suckers and side shoots are removed time to time to maintain single main stem
- Canopy are allowed to developed 1-1.5 m above the ground for convenient intercultural operation in fruit crops

Pruning

- Heading back technique of pruning is practice inorder to maintain the tree canopy and intercultural operations
- Thinning out pruning technique is also practice when there is complete removal of pest or disease infected branches in the tree
- Skirting pruning is practiced when there is removal of hanging of unwanted branches in the tree canopy

Precaution:

- When the fruit trees are old and unproductive rejuvenation pruning are practiced by severe pruning 1.5-2m above the ground and RDF should be given for new flush and vegetative growth
- During rejuvenation pruning, cut end stem portion should be treated with bourdeaux paste or COC to prevent pest and disease incidence on it.

Skill Set (FSC) 12: Layout and establishment of fruit orchards

Skill to impart: Layout and establishment of fruit crops

Tools and materials required: Measuring tap, bamboo stick

Procedure:

Selection site of orchard

- The location should be in a well-established fruit growing region
- There should be a market close to the area.
- The climate should be suitable for growing the chosen fruit crops.
- Adequate water supply should be available round the year and suitability of soil.
- Site must have proper drainage and no water stagnation during rainy season
- Irrigation water must be of good quality

Preliminary operations before the establishment of orchards

- The lands should be thoroughly ploughed, levelled and manure.
- In the hills, the land should be divided into terraces depending upon the topography of the land and the levelling is done within the terraces. Terracing protects the land from erosion

Layout of planting systems

- The plan showing the arrangement of plants in an orchard is known as the orchard layout. There are several systems of planting but square system, rectangular system, quincunx system, hexagonal system and contour system are common. The last one is suitable only on sloppy lands or hills and the others for plains

Calculation of plant population:

Formula for square and rectangular system of planting

Number of plants= Area in metre square /Planting distance in meter (Plant to Plant x Row to Row)

Formula for hedge planting system (plant population)

$$N = \frac{N \text{ X Area in Ha}}{x\ (y+z)}$$

Where, n= plant population

N= No. of rows in a hedge
X= Plant to Plant distance in metre (m)
y= Row to Row distance in metre (m)
z= Hedge to Hedge distance in metre (m)

Skill Set (FSC) 13: Special horticultural practices in horticultural crops

Skill to impart: Special horticultural practices in horticultural crops (fruit crops)

Tools and materials required: Grafting knife, desuckering tool like a crowbar, spade, growth regulator etc

Procedure:

Different special horticultural practices in fruit crops are practiced as good agricultural practices (GAPs) to improve the yield and quality of the fruit.

Girdling in grape: It is done at bajra grain size to increase the berry size by removing 2-3mm wide strip of bark without injuring the wood It should be done before the bajra size. Besides, GA3 @ 60ppm application was also done after attaining the grain bajra size for berry elongation

Desuckering in bananas: Surplus and unwanted suckers should be kept under control for better growth and yield of the mother plant. Desuckering once in 45 days is a common practice in a banana plantation and only 1 sucker should be maintained/mother plant

Earthing up in pineapple: This is an essential operation in pineapple cultivation aimed at good anchorage to the plants. It is more important in ratoon crops as the base of ratoon plants shifts up, crop after crop.

Bending technique in guava: It is done by retaining 10-15 pairs of leaves at the apex removing all the leaves, and flowers and developing fruits manually. Branches were bent dawn by applying pressure gradually from proximal to distal end of branch. This technique helps in more profuse flowering in guava and generally practice in West Bengal.

Crop regulation in guava: Winter guavas are better in taste and more price as compared to rainy season guava. In order to bear more fruits during winter season, rainy season guava can be avoided by application of NAA @ 400-800ppm or I pair leaf pruning of current season shoot.

Precautions:

Crop regulation in guava using NAA concentration for flower thinning differs for different agro-climatic zone. So standardization are needed for it effective application.

Skill Set (FSC) 14: Identification and management of physiological disorder in fruit crops

Skill to impart: Identification and management of physiological disorder in fruit crops

Tools and materials required: Leaves & fruit samples, Fertilizer, PGR etc.

Procedure:

Identification and management of physiological disorders need to be taken in time for effective improvement in yield and quality of the fruit crops. Some of the important disorders and management for fruit crops are -

Mango disorder:

Fruit drop in mango: Based on fruit size, the intensity of fruit drop can be divided the fruit drop into three almost distinct phases and designated as (a) Pin-head drop, (b) post-setting drop and (c) May drop.

Management: Proper nutrient management and irrigation after fruit setting and irrigation should be stop 10 days before harvesting and no irrigation in the initiation of flowering and application of NAA & 2,4-D @ 35 ppm.

Alternate bearing/ Biennial bearing: The tendency of bearing good crop in one year (on year) followed by no crops on lean bearing in subsequent years (off year) is referred as alternative bearing or irregular bearing. Most of the South Indian varieties are regular bearer, whereas North Indian varieties are alternate bearer. In Manipur also some of the local germplasm are alternate bearing in nature.

Management: Deblossoming and fruit thinning- Partial or complete removal of flowers and young fruits in the 'on' year increased slightly during the next year, soil drenching with paclobutrazol (5g/tree).

Black tip of mango: This disorder is mainly occur in nearby brick kiln factory which produce toxic gases like SO2, CO2, CO and acetylene.

Management: The mango orchard should be 600m away from a brick kiln, modification (elongation) in the chimney of the birck kiln for more absorption of smoke and spraying borax @ 0.6% for 10-14 days interval from fruit set.

Mango floral malformation: It main symptoms are the deformation of panicles, suppression of apical dominance, shortened 10 and 20 axes, thickened rachis of panicle and seldom set fruit (if fruit setting occur also it fall down before maturity).

Management: Spraying 100-200ppm NAA during October-November at the fruit bud differentiation followed by manual de-blossoming of the malformed panicle and shoots.

Guava disorder: Bronzing is another common problem in guava. It is caused by the deficiency of B, Zn, N, P and K. Due to low soil pH the soluble P level of leave is a better index for bronzing.

Citrus disorder: Fruit drops: The first wave occurs soon after fruit setting, second during May-June known as June drop and third one known as pre-harvest drop, i.e. the drop of mature fruits before harvesting. Fluctuating temperature, low atmospheric humidity, imbalance of soil moisture, lack of proper nutrition, hormonal imbalance, incidence of insect-pests and diseases are some factors causing fruit drop.

Management: Maintenance of appropriate soil moisture level during fruit development and application of growth regulators – 2, 4-D (10 ppm) or NAA (5 ppm) check fruit drop quite effectively

Granulation: It is a physiological disorder of juice sacs of citrus including mandarins wherein they become comparatively hard, assume a grayish color and become somewhat enlarged.
Management: Application of 2,4-D (12 ppm), zinc 0.5% and copper (0.5%) reduces the incidence of granulation considerably.

Citrus decline: Quick decline is due to virus (tristiza virus / citrus greening) and slow decline is due to improper maintenance/negligence of the orchard.
Management: Use of resistant and compatible rootstocks (Rangpur Lime, Rough Lemon, kachai Lemon) and certified bud wood for propagation (certified virus free planting material) and proper nutrient management.

Pineapple disorder: Multiple crowns: It is associated with high vigour of the plants. High fertility of soil (nitrogen or organic matter and deficiency of zinc micronutrient)
Management: Excess nitrogen fertilizer or organic matter should be avoided than its recommended dose of fertilizer.

Pomegranate disorder: Fruit cracking: It is more prone in hot and dry condition.
Management: Application of water regularly once/week in summer and bi-weekly in winter period during the fruiting period and calcium sulphate (0.2%), boron (0.2%) GA3 @ 15ppm should be apply for control of it.

Internal breakdown: Disintegration of arils in matured fruit of pomegranate is known as internal breakdown or blackening of arils is the symptom of it.
Management: It should be harvested 120-135 days after fruit set and over ripening should be avoided.

Precaution:
Nutrient and disease symptoms are similar in visual like citrus greening and zinc deficiency. Therefore, careful diagnosis needs for identification for effective measures.

Skill Set (FSC) 15: **Horticultural operations and nutrient management in fruit crops**

Skill to impart: Nutrient management in fruit crops

Materials required: Fertilizer, FYM etc

Procedure:

For nutrient management in fruit crops, recommended dose of fertilizer should be applied for each particular crop. Before the application of it, soil around the plant should be dug in circular and fertilizer should be applied. After application, light irrigation should be given. For example-

Mango: 170 gm urea, 110 gm single super phosphate and 115 gm muriate of potash per plant per year of the age from first to tenth year and thereafter 1.7 kg, 1.1 kg, and 1.15 kg respectively of these fertilizers per plant per year can be applied in two equal split doses (June-July and October).

Pineapple: RDF for pineapple is 12g/plant each for N and K_2O and 4g/plant for P_2O_5. The first dose of N is applied 2 months after planting and lasts one 12 months after planting. The K is given in 2 split doses.

The entire P and half K can be applied at the time of planting and the remaining K 6 months after planting. Applications of fertilizer are generally done in onset of monsoon when the soils are in moist conditions.

Precaution:

Excess dose of fertilizer application above RDF for each crop should be avoided since it will hamper the growth and yield of the plant. FYM or vermicompost should be applied along with chemical fertilizer as INM since only chemical fertilizer will hamper the soil in sustainable crop production in the future.

Skill Set (FSC) 16: Harvesting and marketing of fruit crop

Skill to impart: Maturity index of fruit crops

Materials required: Mature fruits for maturity index

Procedure:

Maturity indices are the sign or indication the readiness of the commodity for harvest. It is the basis for determining harvest date whereas physiological maturity is the stage in the development of the fruits and vegetables when maximum growth and maturation has occurred. Some of the important maturity index of fruit crops are-

Mango: Full rounded shoulder and colour of the fruit (yellowing)

Pineapple: Flatness of eye and skin yellowing

Mandarin: Peel colour (yellow)

Apple: Colour of fruit

Pomegranate: Yellowish red in color and the calyx at distal end of the fruit gets closed

Sapota: No green tissue and milky latex are seen on fruits when scratched with nails and calyx free at the tipoff the fruit

Papaya: Colour from dark green to light green with yellow streak from the base upward

Precaution:

- If the fruit is climacteric viz. mango, papaya etc fruits should be harvested at the fully mature stage for distant transport.
- In the case of non-climacteric fruit, fully mature and ripe fruit should be harvested for marketing.
- For fruit crops like strawberries which have very short shelf life, proper market channels should be identified before harvesting since their shelf life is only 1-2 days.

Skill Set (FSC) 17: **Processing plantation crops like tea, rubber, arecanut etc.**

Skill to impart: Processing of plantation crops

Materials required: Plantation crops and its processing unit

Procedure:

Plantation crops require processing unit for the quality production of process products. For this processing unit, good qualities of raw materials are needed and processing steps should be known properly for quality process products.

Tea processing technique:

Generally, two types of processing methods viz., Orthodox method (Traditional method) and cutting, tearing and curling (CTC) method are followed in tea processing.

Irrespective of the method, manufacturing of tea involves the following steps.

Withering: it is done to reduce the moisture content of leaves by spreading them in troughs which receive artificial air from fan fitted on one end. This process takes about 12-18 hours depending on the weather condition.

Rolling: This operation is carried out by a series of machines or in a single roller, during which the cells in the leaves are broken to liberate the sap containing the polyphenol oxidises, an enzyme, which in the presence of oxygen, oxidizes the polyphenol to produce the theaflavins and thearubigens. These are responsible for the colouring of the tea and are a prerequisite for the next process viz., fermentation. Rolling takes place for about 30-40 minutes.

Fermentation: Rolled tea materials are either spread on concrete floors or kept in aluminum trays. In the presence of high humidity and proper temperature, the properties of fermented tea will take a golden red color. This step decides the quality i.e., strength, colour and briskness of tea. It required 1-2 hours depending upon the environmental conditions.

Drying: This step aims at stopping the fermentation process and slowly removing the moisture content without a burnt smell but preserving the inherent quality. This is achieved by passing the fermented tea in thin layers through conveyors into a drier in which the inlet temperature is maintained around 250-280^{0}F and outlet temperature is around 150-200^{0}F. Proper drying takes 30-40 minutes.

Grading: Before grading, the dried tea is removed of the stalk fibers which affect the quality, by passing through fiber separator machines. The bulk tea is passed through different sized meshes which aid in separation into different grades.

Arecanut processing technique:

Kottapak: The most popular trade type of arecanut is the dried, whole nut known as chali or kottapak. Fully ripe, nine to eleven (9-11) months old fruits depending on varieties having yellow to orange-red colour the best suited for the above purpose.

Kalipak: The nuts of 6 to 7 months maturity with dark green colour are dehusked, cut into pieces and boiled with water of dilute extract from previous boiling; a kali coating is given and dried finally. Kali is the concentrated extract obtained from boiling 3 to 4 batches of Kalipak. Many varieties of scented suparies are now prepared by blending the dried, broken bits of arecanut with flavour mixtures and packing.

Iylon: It is mainly consumed in Tamil Nadu and Andhra Pradesh. For processing this product, the nuts are more slightly mature than the kalipak (more than 7 months but not fully riped) and unboiled nuts are used for this product.

Nuli: It is similar to iylon processed product but prepared from very tender nut.

Beeda: Readymade combination of chali or supari along with clove, coconut grating and sugar crystals.

Rubber processing technique:

Preserved latex concentrates: The processing of latex into latex concentrate by centrifugation involves the separation of preserved field latex into two fractions, one containing the concentrated latex of more than 60% dry rubber and the other containing 4-8% dry rubber (skim latex).

Dry ribbed sheet rubber: Anti- coagulants (solutions of ammonia, formalin or sodium sulphite) are added to the cups to prevent the coagulation of latex before it reaches the factory. The latex so collected is bulked and then strained to remove the impurities. It is then diluted to a standard consistency of 12-15% rubber. Special hydrometers like metrolac, and latex meter are employed to measure the percentage of rubber. After dilution, the latex is strained through a 60-mesh screen for the second time.

Dry crepe rubber: When coagulation from latex or any form of field coagulum after necessary preliminary treatments with formic acid or acetic acid for coagulation is passed through a set of creping machines to get crinkly, lace-like rubber called ‘crepe rubber’ after drying. Various grades of crepe rubbers are EPC super 1 X, EPC1X, EPC2X and EPC3X.

Precautions:

Based on the processing of different process products it processing techniques are different. Therefore, skill of each particular process product needs to be understood to obtained quality product.

VEGETABLE SCIENCE

Skill Set (VSC) 1 **: Nursery raising techniques of vegetable crops under protected cultivation**

Skills to impart : Raising of vegetable seedlings under low-cost poly houses, portray, polytunnel, Use of soilless media in portray

Tools and materials **:** Portray, cocopeat, compost, sand

Main phases in Nursery Management

Planning: Done for planting material, land area, water supply, working tools, growing structures and input availability

Implementation: Soil treatment, protection against pest and diseases, proper layout, input supply

Monitoring and evaluation: Rapid response and critical analysis

Procedure

I. Pro Tray (Plug Tray) Nursery Steps

- Pro Tray is to be filled with growing media i.e., a cocopeat small depression (0.5 cm) is to be made with a fingertip in the centre of the cell of the portray to sow the seeds
- One seed per cell is to be followed by covering the cell with medium
- Cocopeat having 300-400% moisture is good to avoid irrigation after sowing
- Entire stack should be covered with polythene sheet to ensure consumption of moisture until germination
- Trays should be protected from hails, heavy rainfall both covering with polythene in the form of low tunnel
- Seedlings at right stage of planting are to be hardened by withholding irrigation

II. Polytunnel nursery

- Seeds are sown in the nursery bed covered with fabricated tunnels of size 3.0 m long, 1.5m width and central height of 1m
- The semi-circular structure is clad with UV polythene sheet with 75% transmittance
- Nutrients are applied @ 2-3 kg/m^2 for FYM/compost
- After sowing, the seeds should be covered with soil and FYM/Compost mixture (2:1)
- Once the seed sowing, covering of seeds, and irrigation are over, the bed can be covered with the tunnel
- Need-based foliar application of vermiwash or compost tea can be done to provide nutrients for raising healthy seedlings
- The ends could also be covered if grown in adverse winters

Skill Set (VSC) 2 **: Quality organic seed production of tomato.**

Skills to impart : Organic seed production of tomato, Seed extraction of tomato, Seed Testing and its enhancement for good quality seed production

Procedure:

A. Cultivation of Tomato for seed production

- **Nursery:** Sow the seeds in a raised nursery bed of 20 cm in height, in rows of 5 cm gap and covered with sand. Eight to ten nursery beds will be sufficient to transplant one acre.
- **Transplanting:** Transplanting should be done with the seedlings that are 20-25 days old, preferably at evening time. Spacing is 60 x 45 cm (90 x 60 cm for female parent and 60 x 45 cm for male parent of hybrids).
- **Manuring:** After thorough preparation of the field to fine tilth, apply 25 tons of FYM per ha.
- **Roguing:** It should be done based on the plant characters (determinate/indeterminate), leaf, branching, and spreading characters and also based on fruit size, shape, and colour. The plants affected by early blight, leaf spot, and mosaic (TMV) diseases should be removed from the seed production field.
- **Planting ratio:** In hybrid seed production, the female and male parents are normally planted in the ratio of 12:1 or 12:2.
- **Pest and disease management:** The major pests attacking tomato crop are tomato Fruit borer (*Helicoverpa armigera*), Serpentine leaf miner (*Liriomyza trifolii*), Whitefly (*Bemisia tabaci*), Early blight (*Alternaria solani, A. alternatea* f.sp. *lycopersici*). Some of the managements are: Avoid growing of solanaceous crops such as chili and brinjal, after tomato to avoid the carry-over of pests and diseases from one season to the other; Seedlings treatment with *Trichoderma asperellum* / *Pseudomonas fluorescens* @ 5g/ l for 10-15 minutes before transplanting.
- **Harvesting seed extraction and processing:** The fruits are harvested after full maturity of the fruit when it turns into red colour. Fruits from the first and last one or two harvests should not be used for seed extraction.

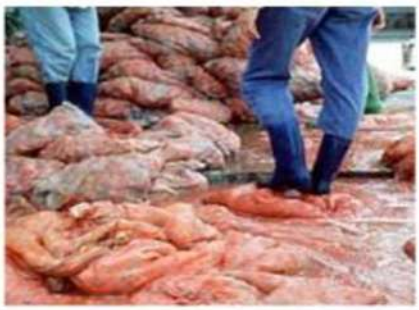
B. Seed extraction of tomato: 3 ways

Fermentation: Mix fruit pulp with water and ferment it for 24- 48 hours.

Acid: Add HCl @ 25 ml/1 kg of pulp and leave it for 20-30 minutes

Alkali: To hasten the fermentation process 0.5% sodium bicarbonate (500 g dissolved in 10 l of warm water is added to the pulp and allowed to remain for a day. Then, the seeds are separated and washed free of alkali with water.

Fermentation method



Manual Crushing

Fermentation

Washing

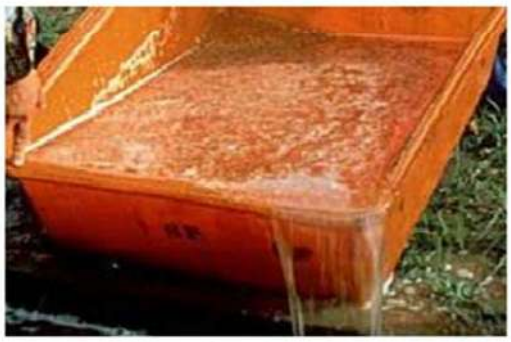
Extracted seed

Acid seed extraction

Mechanical Crushing

Extracted seed

Acid treatment



Washing of seeds

Fig.: Seed extraction process of tomato

C. Seed Germination Test

Seed in sand (S): Seeds are planted in a uniform layer of moist sand and then covered to a depth of 1 to 2 cm with sand.

Top of sand (TS): Seeds are pressed into the surface of the sand. Equal spacing on all sides should be maintained to facilitate normal growth of seedling and to avoid entangling of seed and spread of disease. Spacing should be 1-5 times the width or diameter of the seed. The amount of water to be added to the sand will depend on the size of the seed. For cereals, except maize, the sand can be moistened to 50% of its water holding capacity. For large, seeded legumes, and maize, sand is moistened to 60% water-holding capacity.

Top of paper (TP): Seeds are placed on one or more layers of moist filter paper or blotter paper in Petri plates. These Petri plates are covered with a lid and placed inside the germination cabinet. This is suitable for those seeds which require light.

Between paper (BP): The seeds are germinated between two layers of paper. The seeds are placed between two layers of paper and rolled in towels. The rolled towels are placed in the germinator in an upright position.

Skill Set (VSC) 3: Hybrid development in dalle chilli

Skills to impart: Selection of parental lines, Development of inbred lines, Emasculation and pollination techniques

Materials required: Forceps, camel brush, Muslin cloth, paper tags, Aluminum tags, Cotton and Butter paper

Propagation method : Seeds

Ideal season: April to September

Procedure:

- Emasculation is done before the anthers are mature and the stigma has become receptive to minimize accidental self-pollination.
- Emasculation is generally done in the evening, between 4 pm and 6 pm one day before the anthers are expected to dehisce or mature and the stigma is likely to become fully receptive
- Emasculate the bud by hand with the help of a needle and forceps. Remove the calyx, corolla, and staminal column or anthers, leaving gynoecium i.e., stigma and style intact in the flower.
- Emasculated flowers should be covered immediately with red coloured paper cover to protect against contamination from foreign pollen and also for easy identification of emasculated bud during dusting.
- Remove the red paper cover of the emasculated bud and dust the pollen gently over the stigmatic surface using cotton or camel brush, etc.,
- After dusting, the emasculated flowers are again covered with white or other coloured paper cover for two to three days.
- Pollen collected from one male flower can be used for dusting 5 to 7 emasculated flowers

Skill Set (VSC) 4: Measurement of maturity standards of vegetables

Skills to impart: To identify the harvesting stage of a particular vegetable as per requirement, to learn harvesting techniques.

Introduction:

- The time of harvest is determined by the maturity and quality of the vegetable.
- Maturation is the indicative of fruit or plant part of a vegetable being ready for harvest. Good quality vegetables are a combination of flavour, texture appearance, and food value which gives pleasure or satisfaction to the consumer.

Crop	Maturity indices/standards and method of harvesting
Tomato	Development of jelly in the locules and at least attain mature green stage for the distant market. Pink and ripe stage of fruit for the local market. 
Chilli	The picking of fruits depends upon the type and purpose for which they are grown: i) Green fruits: Fruits are harvested when they are still green but fully grown. It needs 5-6 pickings for harvesting the whole crop. ii) Pickles: The fruits are harvested either green or ripe. iii) Drying: Red fully ripe fruits are picked at an interval of 1-2 weeks and harvesting continues for about 3 months. The ripe chillies are dried under sun for 8-15 days, while commercially it is dried at about 54°C in 2-3 days. 
Brinjal	Tender fruit with desirable size having soft seeds. If fruit is yellow in colour and seedy it indicates overmature. Pick brinjal when their colour is bright and glossy. Once they lose their shine, they are too old. Pick the fruit like capsicum. 
Okra (Lady's finger)	Desirable fruit size (5-10 cm long) and tender. Tips of fruits and base/peduncle can easily be snapped. The tender, green and small pods should be picked in the morning or evening. While picking okra, one should wear gloves or wash his hands thoroughly after picking in order to remove the irritating and stinging effect of the bristles of the fruits. 
Watermelon	Watermelon is harvested at the fully ripe stage. Maturity signs are withering of the tendril, change in belly colour or ground spots to yellow and the thumping test produces a dull sound on maturity  Water melon ripen stage

	and a metallic sound in unripe fruits. The metallic sound from thumping the fruit is for shipping and a dull hollow sound when thumping is for immediate use.
Pumpkins, ash gourd and winter squash	 **Pumpkin, Winter quash and Ash gourd:** Harvest them when they are matured on vine.
Musk melon (cantaloupes) & Snap melon	Full slip stage easily separated from the vine with a slight twist living clean cavity is for immediate use whereas the half-slip stage is for shipping.  Maturity indices of Musk melon at half slip and full slip stage
Cauliflower, cabbage and broccoli	Curd compact, well developed, and at least 15 cm in diameter of cauliflower curd. The head is compact, well developed with at least 750-1000 g of weight in the case of cabbage whereas, for broccoli, the bud cluster is compact, has an adequate diameter, and all florets should be closed. 

Skill Set (VSC) 5: Training and pruning of vegetable crops under polyhouse.

Skills to impart: Training and Pruning of Vegetable Crops

The primary objective of training and pruning of Vegetable crops in a polyhouse is to enhance the overall productivity and profitability of crops by creating a controlled environment that maximizes light exposure, improves air circulation, and facilitates efficient nutrient and water management.

PROCEDURE:

1. Understanding Crop Growth and Varieties

Growth Habits:

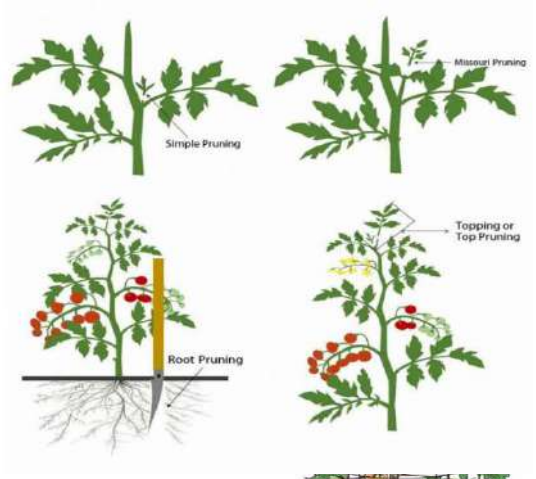
a. Determinate Varieties: Bushy growth with a finite flowering period.

b. Indeterminate Varieties: Vining growth with continuous flowering and fruiting.

Selection Criteria:

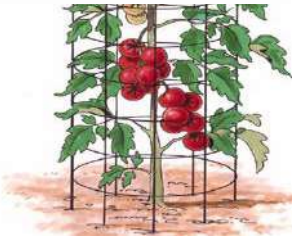
a. Disease Resistance: Choose varieties resistant to common diseases.

b. Yield Potential: opt for high-yielding varieties.



➢ Climate Adaptability:

Select varieties suitable for polyhouse conditions.



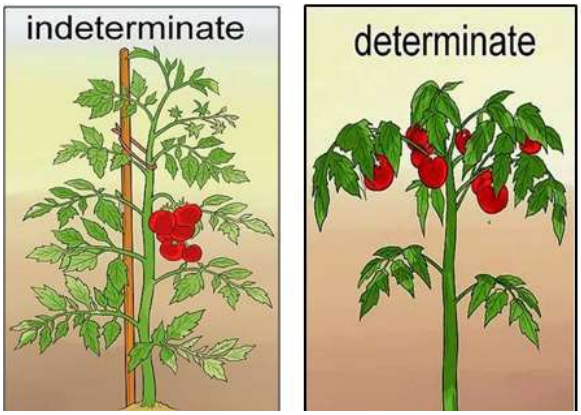
2. Essential Tools and Materials

Tools:

a. Pruning Shears: Sharp and clean for precise cuts.

b. Sanitization Materials: Alcohol or bleach solution for disinfecting tools.

Materials:



a. Stakes: Wooden or metal stakes for plant support.

b. Cages and Trellises: Structures to support and guide plant growth.

c. String and Clips: For securing plants to support systems.

3. Training Techniques

Staking:

Materials Needed: Stakes, twine, or plant ties.

Method: Insert stakes 1-2 inches from the plant base and tie the main stem to the stake using soft ties or twine.

Caging:

Types of Cages: Circular or square cages.

Installation: Place cages around young plants, ensuring they are securely anchored in the soil.

Trellising:

Trellis Designs: Vertical or A-frame trellises.

Training Method: Use clips or ties to secure the plant stems to the trellis as they grow.

String Training:

Setup: Attach strings from the greenhouse roof to the base of each plant.

Securing Plants: Wind the plant stems around the strings as they grow, using clips to secure them if necessary.

4. **Pruning Techniques**

Initial Pruning:

Timing: Start when plants are 6-8 inches tall.

Method: Remove the lower leaves and any suckers below the first flower cluster to encourage strong central stem growth.

Suckering:

Identifying Suckers: Suckers are the shoots that develop in the axils between the main stem and branches.

Removal: Pinch or cut off suckers when they are small to direct the plant's energy towards fruit production.

Leaf Pruning:

Benefits: Improves air circulation and reduces disease risk.

Technique: Remove lower leaves that touch the soil and any diseased or damaged leaves.

Top Pruning:

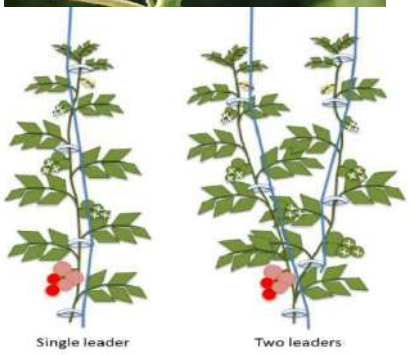
Purpose: Control plant height and encourage bushier growth.

Method: Pinch or cut off the growing tip of the main stem once the plant reaches the desired height.

Flower Cluster Pruning:

Improving Fruit Quality: Thin out excess flower clusters to ensure larger, healthier fruits.

Technique: Remove smaller or misshapen flowers, leaving the healthiest ones to develop into fruits.



5. **Timing and Frequency of Pruning**

Early Season Pruning:

Timing: Begin within the first few weeks of planting.

Objective: Shape young plants and remove excess growth to establish a strong structure.

Ongoing Maintenance:

Regular Schedule: Prune every 1-2 weeks throughout the growing season.

Adjustments: Adapt pruning intensity based on plant growth and health. Increase or decrease pruning frequency and intensity based on the plant's growth stage and environmental conditions.

6. **Tool Proficiency and Maintenance**

Pruning Shears:

Selection: Choose high-quality, sharp shears for clean cuts.

Maintenance: Regularly sharpen and clean shears to prevent disease transmission and ensure efficient pruning.

Sanitization Practices: Disinfect pruning tools between cuts to prevent the spread of diseases. Use alcohol or a bleach solution to sanitize tools.

7. Understanding Plant Physiology and Pruning Impact

Photosynthesis and Energy Distribution:

Effect of Pruning: Pruning redirects the plant's energy from excessive vegetative growth to fruit production, enhancing photosynthesis efficiency.

Hormonal Responses (Auxins and Cytokinins): Pruning influences the distribution of plant hormones, promoting balanced growth and development.

8. Problem-solving and Adaptation

Disease and Pest Identification:

Identify and manage diseases like powdery mildew and pests such as aphids and spider mites.

Integrated Pest Management (IPM): Use a combination of biological, cultural, and chemical controls to manage pests and diseases.

Adapting Techniques:

Environmental Conditions: Modify training and pruning practices based on the specific climate and conditions within the polyhouse.

9. Record-Keeping and Monitoring

Documentation Practices:

Maintain detailed records of pruning schedules, methods used, and observed outcomes.

Data Analysis: Use records to analyze plant performance and refine techniques.

Monitoring Growth and Health: Conduct frequent inspections of plant health and growth. Use monitoring data to make informed decisions about training and pruning adjustments.

10. Communication and Training

Teaching Pruning Techniques:

Provide hands-on training and demonstrations for workers and gardeners.

Develop manuals and guides to support training efforts.

Offer advice on best practices for training and pruning to optimize bell pepper production.

Engage with the grower community to share experiences and insights.

11. Safety Practices

- Adopt environmentally friendly practices to minimize negative impacts on the polyhouse ecosystem.
- Encourage the presence of beneficial organisms that contribute to pest control and plant health.

FLORICULTURE AND LANDSCAPING

Skill Set (FLS) 1: Propagation of chrysanthemum *(Dendranthema morifolium)*

Skills to impart: Hands-on-training practices on propagation of chrysanthemum through cuttings, technical knowhow on raising cuttings in chrysanthemum

Tools and Materials: Secateur, portray, Polybag, Rootex, Fungicide, Potting media (cocopeat)

Ideal Season: Spring season (February-March)

Ideal climate: 18-21^{0}C, Net house or shade house

Ideal age of plants: 20-25 days

Technical Knowhow:

- Select mother plants free from pest and disease infestation during the spring season
- Cut the terminal stem having 4-6 cm long with basal stem diameter between 3.2 to 4.8 mm with sharp secateur
- The cut end portion should be dipped in Rootex No. 1 to induce rooting
- For raising of cuttings, the cut stem should be planted in a portrays or polybags with potting media cocopeat
- Make a hole in the middle of the pot and place the cutting 1-inch-deep compress growing media slightly to keep the cutting upright
- Place the cuttings in polytunnel to maintain high humidity
- Watering of the cuttings should be done at day intervals or three times a week depending on the dryness of the growing media
- Spray Dithane M-45 at 0.02% to avoid damping off
- Rooting is indicated by the emergence of new growth in the tip portion of the stem which occurs within a week after cutting
- Transplanting of rooted cuttings to the main field or pots can be done during May-August

Skill Set (FLS) 2: Skeletonization of leaves

Skills to impart:

- Hands-on-training practices on the skeletonization of leaves
- Preparation of value-added products from skeletonized leaves like paper bags, greeting cards, table décor, wall décor, etc.

Tools and materials: Secateur, Polybag, Sodium hydroxide/Washing soda/lye, distilled water, Water boiler, spatula, soft toothbrush

Method of drying: Skeletonization

***Plant* sample**: Leaves of Peepal, Magnolia

Stage of collection: Fully matured leaves

Procedure:

- Matured leaves with heavy texture should be selected for skeletonization. Skeletonized leaves lend an interesting, lacy appearance to dried arrangements.
- Leaves are boiled for 30-40 minutes in a solution containing a quarter of water and 2 tablespoons of lye and rinsed in cold water.
- The green portion is scraped or brushed with the help of a soft toothbrush from the leaves without destroying the network of veins.
- If the green portion remains, it is again immersed in the boiling solution till the veins remain.
- This is followed by rinsing of the leaves and drying them in the shade for further use.

Skill Set (FLS) 3: Dry flower technology

Skills to impart: Hands-on-training practices on making dry flowers by different methods

Tools and Materials: Secateur, Microwave Oven, Silica sand, Hanging rack, Rope

Name of Crops: Rose, Chrysanthemum, Helichrysum, Statice, Gypsophila etc.

Procedure for Different Methods of Flower Drying:

Press Drying:

- Flowers and Foliage are placed in between two folds of newspaper sheets or blotting paper and these sheets are kept one over another and corrugated boards of the same size are placed in between the folded sheets to allow the water vapour to escape.
- The whole bundle is then placed in the plant press, its screws tightened.
- After 24 hours the bundle is removed to an electric hot air oven for 24 hours at 40- 450 C.
- Placing the foliage between two pieces of waxed paper and pressing the wax paper with a medium-hot iron easily preserves the flexibility and the fall colors of the foliage.
- New pieces of waxed paper must be used for each pressing.

Air drying:

- Select Cut flowers of good quality slightly immature.
- Remove foliage from stems. If stems are weak or become brittle after drying, remove them and wire the flowers.
- Group the stems into small bunches and tie them with a rubber band. It will pull tighter as the stems shrink during drying.
- Hang upside down in a warm, dry, dark area such as an attic, closet or furnace room. Avoid damp rooms or direct sun on the flowers. Good air circulation is important.

- Allow to remain until thoroughly dried. This normally takes two to three weeks**.**

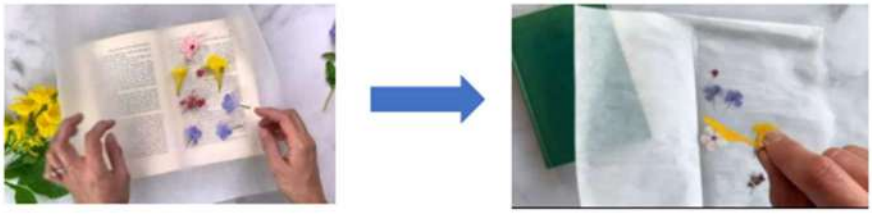


Fig. 1 Drying of flowers by Press Drying

Fig. 2 Drying of flowers by Air Drying

Oven Drying:

- Electrically operated hot air oven at a controlled temperature of 40-50 is used for drying flowers in an embedded condition.

Sun Drying:

- Plant material is embedded in a drying medium (sand) in a container and exposed to the sun daily to facilitate rapid dehydration.
- Flowers like zinnias, marigolds, pansies, and pompon chrysanthemums embedded in sand in an upside-down fashion and kept in the sun would dry in a day or two.

Embedding Method:

- Embedding the flowers in a granular, desiccating material.
- Sand, Borax, kitty's litter, Silica gel, sawdust, perlite and a combination of these materials are used in this method.

Microwave Oven Drying:

- The flower must be embedded in silica gel medium in a microwave-safe open container and a small cup with water nearby.
- A standing time of 10 minutes to a few hours is needed after the drying for best results.
- When the temperature of the silica gel reaches about 160º F, it is done.

Skill Set (FLS) 4: **Production technology of orchids**

Skills to impart: Scientific cultivation techniques of orchids

Growing Requirement
Light: 3000–6000 foot candles
Temperature: 15-32°C
Humidity: 60-80%

Growing Structures
Shadehose

Propagation

Conventional methods

I. Monopodial orchids

A. Stem cuttings

B. Flower stalk cuttings

C. Layering

II. Sympodial orchids

A. Divisions

B. Offshoots

C. Back bulbs

Commercial method

A. Micropropagation






Media

For terrestrial orchids:

- One part rich humus with decayed leaf mould half a part of decomposed and dried compost, one part of sphagnum moss or coir pit mixture.

For epiphytic orchids:

- Coconut husk
- Tiles and bricks
- Charcoal
- Pine bark




General considerations of the media:

- They should hold sufficient amount of moisture, which should be released to the plants when needed.
- They should provide adequate drainage.
- They should be easily available locally.
- They should be cheap or less costly.
- They should not contain substances that are toxic to orchids.
- They should retain nutrients for a reasonable period of time and at the same time should be easily washable so that the accumulating salts of fertilizers do not build up dangerous levels.
- They should be easily workable since potting is tedious, consuming much labour and time.

Fertilizer Application

- NPK 19:19:19 or 20:20:20, dissolved in water @1-5g per litre applied once or twice a week gives satisfactory results.

Skill Set (FLS) 5: **Nursery raising techniques of important flowering annuals**

Skills to impart: Raising of flowering annuals by using soilless media

Task 1: Selection of flowering annuals

- Summer flowering annuals: Zinnia, Vinca, Cockscomb, Balsam, Verbena
- Winter flowering annuals: Petunia, Marigold, Dianthus, Salvia, Antirrhinum, Hollyhock, Pansy, calendula

Task 2: Preparation of media for sowing of seeds.

Activity- Preparation of soilless growing medium.

Materials required: coco peat, vermiculite, perlite, pot or portray, fungicide.

Procedure:

- Prepare composite mixture of coco peat, vermiculite and perlite in 3: 1: 1 volume by volume ratio.
- Treat the media with fungicides.
- Fill the pot or tray with the treated media.

Task 3: Techniques for sowing different seasonal flowers

Activity: Sowing methods.

Procedure

- Line sowing: Seeds of large size should be placed singly in a line for effective usage of seed. e.g.: Zinnia, dahlia, marigold etc.

- Broadcasting: Flower seeds with very small size should be broadcasted uniformly. e.g.: Petunia, dianthus, cockscomb etc.

Task 4: Transplanting and raising of flowers inside polyhouses condition.

Activity-1: Transplanting:

The seedling are ready to transplant when it starts showing 1-2 sets of true leaves. Potting media (soil, FYM and rice hull in 2: 1: 1 v/v ratio) is suitable.

Activity-2: Aftercare:

Irrigation: During summer irrigation should be done every day and in winter every alternate days.

Weeding: Manual weeding can be done as and when required.

Intercultural operation: Pinching at 30-45 days after transplanting

Nutrition: Liquid fertilizer to be sprayed during its growing period @ 2ml/l every 2 weeks

Task 5: Marketing of flowers

Activity-1: Students: Marketing can be carried out through students inside and in and around the campus.

Activity – 2: Through College Outlet Shop: The nursery or flowering annuals can be sold in the college outlet shop at college approved rate.

Activity – 3: Through Nurseries or Flower shops: The flowering annuals can be marketed through the nurseries or flower shop located nearby.

POST HARVEST MANAGEMENT (PHM)

Skill Set (PHM) 1: Dehydrated ginger powder

Skills to impart : Hands-on-practice on the preparation of dehydrated ginger powder/flakes, Packaging, Labelling

Tools and materials: Fresh ginger, weighing scale, Washer cum Peeler, Slicer, Dryer, Polisher, Grinder, Packing machine

Procedure:

- **Harvesting:** Choose fresh and disease-free ginger as quality of powder depends on quality of ginger rhizomes
- **Cleaning and Washing:** Cleaning of harvested rhizomes should be necessary to remove debris, shoots and roots
- **Sorting:** Separation of damaged and injured rhizomes
- **Peeling:** Peeling to remove the scaly epidermis and facilitate drying.
- **Drying:** Drying temperature should be between 55– 60^{o}C and should not exceed 65^{o}C to maintain quality of ginger powder.
- **Milling/ grinding:** Operations to prepare ginger powder
- **Sieving and Packing:** The powdered dry ginger should be sieved through a mesh. The ginger powder are packed in packaging suitable materials.

Skill Set (PHM) 2: Preparation of ready to serve from Sikkim mandarin

Skills to impart: Preparation of RTS from Sikkim mandarin, Bottling, Labeling

Tools and materials: Mature fruits, Sugar, Water, KMS, Glass/PP bottles, weighing balance, Peeler, Juice extractor, Mixing tank, Ladle, gas/electric burner, Crown corking machine

Ingredients used: Sikkim Mandarin juice (1.0 litre), Water (7.8 litre), Sugar (1.2 kg), KMS (1.5 g)

Procedure:

- Take fruit pulp/juice and mix with syrup which is prepared by mixing sugar with water and citric acid
- Homogenize the mixture for proper mixing
- Heat the drink to boil for pasteurization
- Fill in the glass bottles (200ml capacity) while still hot
- Crown cork the bottles and process in boiling water for 20-25 minutes
- On cooling, label the bottles and store in cool and dry place
- Potassium metabisulphite (KMS) can be added to the RTS drink as preservative.

Skill Set (PHM) 3 : Processing of jackfruit pickle

Skills to impart : Preparation of jackfruit pickle

Tools and materials : Immature jackfruit (5-6 small immature), Mustard oil- 2litres, Salt (as per taste), Chilli powder (3-4 tablespoon), Chilli flakes (as per choice), Garlic (1/2kg), Ginger (1 bunch), Panch phoron masala (3-4 tablespoon), Turmeric (3-4 tablespoon), Vinegar (50ml)

Procedure:

1. Peeling
2. Shredding
3. Boiling with salt and turmeric powder
4. Mixing of spices
5. Frying
6. Packaging

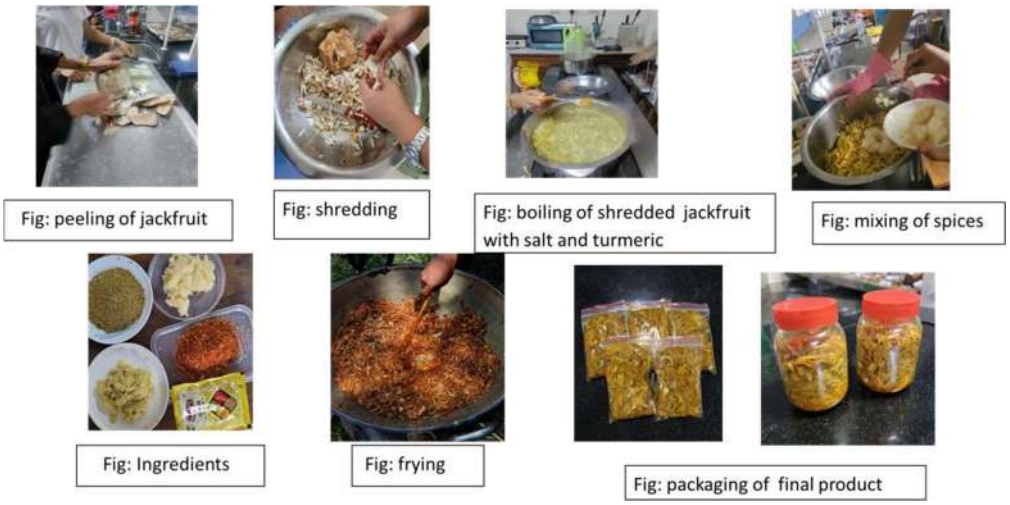


Fig: Steps in preparation of Jackfruit pickle

Skill Set (PHM) 4 : Preparation of tamarind candy

Skills to impart : Hands on preparation of tamarind candy, packaging and labelling materials

Materials required : Tamarind, sugar, chilli,

Procedure:

1. Peeling of tamarind
2. Preparation of sugar solution
3. Coating on tamarind
4. Addition of chilli powder

5. Cook and cool for few minutes
6. Grind sugar powder coating
7. Round shaped candy
8. Packing & labeling

Skill Set (PHM) 5 : Preparation of aonla murabba

Skills to impart : Hands on preparation of aonla murabba, packaging, labelling

Ingredients required : Aonla, sugar, citric acid, KMS

Procedure:

- Washing and sorting of aonla
- Boiling of the Aonla fruit
- Check the softness of the fruit (not to overcook)
- Drain the hot water
- Wash the fruit with cold water
- Spread on the bamboo basket to dry moisture
- Pierce the hole in fruit
- Add sugar in fruit and stir for coating
- Check TSS 42^{o}Brix
- Make sugar syrup, cardamom, and KMS
- Add syrup in sugar-coated aonla balls
- Sterilize the jar and cap
- Fill this final product of aonla in Jars
- Packing & labeling

Skill set (PHM) 6: Preparation of cassava chips

Skills to impart: Practice on preparation of cassava chips, packaging, labelling

Tools and Materials: Cassava, Salt, Knives, Slicer, Fryer, Packaging materials, PP Sealing machine.

Procedure:

1. Selection of immature cassava tuber (7-8months).
2. Peeling and washing of the tubers.
3. Slicing of tubers with manual or mechanical slicer.
4. Soaking the chips in acetic acid-brine solution for 1 hour followed by parboiling for 5 minutes

5. Surface drying by spreading under the fan.
6. Frying in oil.
7. Mixing with salt and other seasoning materials.
8. Packaging, sealing and labeling.

	
Immature Cassava	Peeled cassava
	
Surface drying	Cassava chips

SPICES AND MEDICINAL PLANTS (SMP)

Skill Set (SMP) 1 : Cultivation and marketing of black turmeric (*Curcuma caesia*)

Skills to impart : Hands-on-training practices on cultivation of black turmeric, technical know-how on harvesting and postharvest management.

Propagation method: Rhizomes

Planting season: March to June

Ideal age of plant for good harvest: 2 to 3 years old

Package of Practices

- Climate – Tropical and Subtropical
- Soil – Light and Fertile soil
- Land Preparations - Soil should be ploughed 2-3 times. Plant ridges should be 15 – 20 cm high. Mix FYM as organic manure as much as possible
- Planting material and seed rate - Rhizome is planting material. Healthy and disease-free rhizomes should be selected for planting. Round-shaped rhizomes, about 20 – 25cm, are best as planting material. Around 1000 to 1500 kg of fresh rhizome is needed to cover one hectare of land.
- Spacing – 15x45 cm, 20x45 cm
- Harvesting – Harvesting is done when the leaves turn yellow in the months of December and January. Harvesting is done by using tractors or manual uprooting

Post Harvest Management

Cleaning and grading of the rhizomes needs to be done as soon as it is harvested

The next step is:

Curing: Curing of turmeric fingers is a postharvest activity in which fingers are boiled using water.

Drying: Sun drying; Air drying; Oven drying

Skill Set (SMP) 2: Preparation of nursery beds and seed sowing for raising healthy seedlings of spices

Skills to impart: Preparation of bed, raising of vegetable seedlings

Procedure:

Selection of location and site

The area selected should be well-drained and free from water logging.

There should be proper sunlight from morning till evening.

A. Soil Treatment

- **Fumigation:** A mixture of one gallon (3.8 litres) of the commercial formalin (37 percent strength) with 50 gallon (190 litres) of water is applied @ 21 to 42 litre per square metre.
- **Soil drenching:** Soil drenching was done with Captan @2g/L of water and applied to soil till it was completely saturated with water up to a depth of 15 cm to control soil borne diseases.



B. Raising Nursery on Beds

- For the preparation of beds, the field should be ploughed or dug to a fine texture about 25-30 cm deep and leveled well with the help of a rake.
- Mix up the garden soil, sand and FYM at the ratio of 2:0.5:0.5, respectively.
- Remove weeds, weed roots and stones. Mix up the garden soil, sand and FYM at the ratio of 2:0.5:0.5, respectively.
- Prepare beds of 120 cm wide and length should be selected according to convenience. In between two beds, leave a space of 25-30 cm.
- For rainy season crops, the beds should be kept 15-20 cm high from the soil surface.
- Treat the seeds with Captan or Thiram @ 3 g per kg of seed before sowing.
- Sow the seeds by opening miniature furrows about 2-4 cm deep and 8-10 cm apart in the prepared beds.
- Seeds of cabbage, cauliflower, chili, brinjal, tomato etc., are sown 1.0-1.5 cm deep.
- Cover with thin layer of paddy straw to avoid crust formation and irrigate to keep the bed moist.



C. Diseases and Insect Pests of Nursery Plants

- Damping off seedling disease commonly occurs in poorly managed nursery beds.
- The disease outbreak is characterized by toppling over the infected seedlings at any time after their emergence from soil.
- Treating the seeds with Captan or Thiram @3g per kg of seed before sowing can control it.

D. Essential Operation in Nursery Raising

- **Mulching:** Immediately after seed sowing about 5cm thick layer of mulch (farm residues) over the bed to conserve moisture in the soil.

- **Hardening Off:** This is a practice of exposing the plants to full sunlight and withholding the irrigation for seven to ten days before transplanting so as to make the plant tolerate external growing conditions. Transplant the hardened seedlings in the main field in the afternoon and followed by irrigation.

AGRICULTURAL ENGINEERING & FOOD TECHNOLOGY

PROCESSING AND FOOD ENGINEERING (PFE)

Skill Set (PFE) 1 : Measurement of size and color of agricultural products

Skills to impart : Measurement of some physical properties of agricultural products

Tools and materials : Vernier caliper, and chromameter

Size is the measure of dimension which can be expressed in terms of length, breath, thickness or diameter. Measuring the size of irregular cereals is usually done using a Vernier caliper.

Procedure:

- Take ten specimen samples of paddy/wheat/corn etc.
- Make the two measuring jaws of the micrometer apart for a distance about the apparent size of the specimen.
- Take the sample specimen and bring it in between the jaws of the caliper.
- Bring back the movable jaw towards the specimen gently in such a position that both jaws of the caliper just touch the edges of the specimen.
- Measure the length, breadth and thickness of sample 1 and take caliper readings (for ellipsoid measure major axes). Note the readings in the observation table.
- Repeat the above procedure and measure for all the remaining samples too and note the readings.
- Calculate average length, breadth and thickness separately.

Determination of color:

Surface color of food product is measured as reflected color in terms of (L*, a*, b*) color space using a chroma meter (CR-410, Konica Minolta, Japan). The color coordinates of L* measures (darkness/whiteness), a* (greenness/ redness), b* (blueness/yellowness)

Procedure:

- Switch on the chromameter
- Calibrate the chroma meter against white plate
- Place the sample below the sensor of the chroma meter
- Record the L*, a* and b* values of the sample

Fig. Measurement of color using chromameter

Skill Set (PFE) 2: Measurement of bulk density, and true density of samples

Skills to impart: Measurement of some physical properties of agricultural produce

Tools and materials: Bulk density apparatus, electronic balance, grains, and scale

Bulk density is a physical property of granular materials. It is defined as the ratio of weight of material to unit volume in bulk. The bulk density of a granular product is the density measured without the influence of any compression on the product. The bulk density depends on particle density, its shape and the way the constituent particles are packed or positioned with respect to each other.

Mathematically, $Bulk\ density = \frac{\text{Weight of material,Kg}}{\text{Volume of material,m}^3}$

The unit of bulk density in the metric system is kg/m^3. This property is important in various aspects of agricultural engineering designs. For example, designing the capacity of a grain storage structure bulk density is required. The bulk density can also be expressed in kg/hector-litre by the following formula.

Bulk density = (m x 0.2) kg/hector-litre.

Where, m = weight of product in grams.

The apparatus for measuring bulk density consists of a kettle, pan (or funnel), and wooden stroker. The capacity of the kettle is 500 ml. The inside diameter is 8.5 cm and the height is 8.8 cm. Its sensitivity while filled with water should be +/- 5 ml.

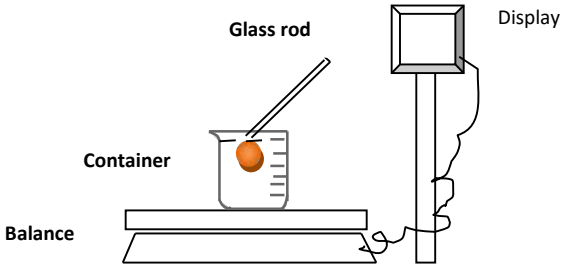
Procedure:

1. Take 1kg of grain.
2. Set the bulk density apparatus in such a way that the height of the pan/funnel from top level of the kettle should be 15 cm and the line of flow of grains should be at the centre of the kettle.
3. Close the flow opening and fill with the grain. The quantity of grains should be more than the capacity of the kettle.
4. Allow the grains to flow freely without any external force by slowly opening the funnel.
5. Remove the extra grains by scrapping from one edge of the kettle with a scale gently. (it can be considered that grains filled in this manner are under no compaction)

6. Take weight of the container with grains and then again without grains. Calculate the difference as weight of grains.
7. Repeat for three replications and take the average weight of grains.
8. Measure the inside diameter and height of the kettle and calculate volume of kettle.
9. Calculate bulk density by using the above formula in kg/m^3.
10. Alternatively, calculate in terms of kg/hector-litre also.

Determination of true density

The density and specific gravity values of grains and other commodities are used in the design of storage bins and silos, separation of desirable materials from impurities, cleaning and grading, evaluation of the grain maturity, texture and softness of fruits, quality evaluation of the product, etc. Some of the agricultural products having irregular shapes, small sizes, and void spaces, pose certain problems in the measurement of volume and density. The volume of such irregular shape material is generally determined by the volume displacement method.



Platform scale measuring volume

Use of platform scale is a simple technique which is commonly used for determination of volume of large materials like fruits and vegetables. The volume of such materials can be measured by the following procedure.

Materials required: Bio-samples, platform scale, glass rod and water.

Procedure:

i. Take weight of the material in air and note down.
ii. Take a 500 ml beaker and fill it with water about half of the volume.
iii. Measure the weight of beaker and water together.
iv. Put the material into the beaker and force it to just submerge with the help of a rod.
v. Measure the total weight at the above condition on the scale and record the reading.
vi. Subtract the weight reading at step iii from the weight reading at step v as to give weight of displaced water.

Skill Set (PFE) 3: Measurement of textural properties of food materials

Skills to impart: Measurement of the texture of agricultural produce

Tools and materials: Texture analyzer

The textural terms may be expressed as hardness, softness, springiness, chewiness, crispiness, oiliness, fluidness, creaminess, etc. as filled by the mouth or finger. In the case of fruits and vegetables, the textural parameters can be related to the level of maturity such as the degree of ripening, etc. The compositional or structural changes during the storage period of fruits and vegetables can also be related to the texture.

Textural parameters are normally perceived during the sensory evaluation of food. However, expressing the value of texture in numerical figures be possible. Therefore, measurement of texture by using an instrument provides the solution by putting values to traditional subjective characteristic of the food. Using Mechanical means, through the use of a food texture analyser, it is possible to imitate the actions undertaken by a person when consuming the product to measure crispness, Hardness, Juiciness, Toughness, Mealium, and Fibrousness, etc.

The texture analyzer is a microprocessor-controlled texture analysis system, which can be interfaced to a wide range of peripherals, including PC-type computers. The texture analyzer measures force, distance and time in a most basic test, thus providing three-dimensional product analysis.

Many tests can be performed with suitable probes for measuring different textural parameters of agricultural and food materials. The common tests of texture may be as below.

1) Puncture/firmness test
2) Cutting / Shearing test
3) Compression test
4) Tension test
5) Springiness test
6) Crispiness test
7) Gumminess

A simple can be a puncture test for measuring the firmness, compression test for hardness and cutting test for food materials.

Puncture test, compression test and cutting test using a TA. HD Plus (Stable Micro Systems) food texture analyser: The puncture, compression and cutting test of a food sample can be performed with the following procedure.

Materials required: Food Texture Analyzer, probes and food samples.

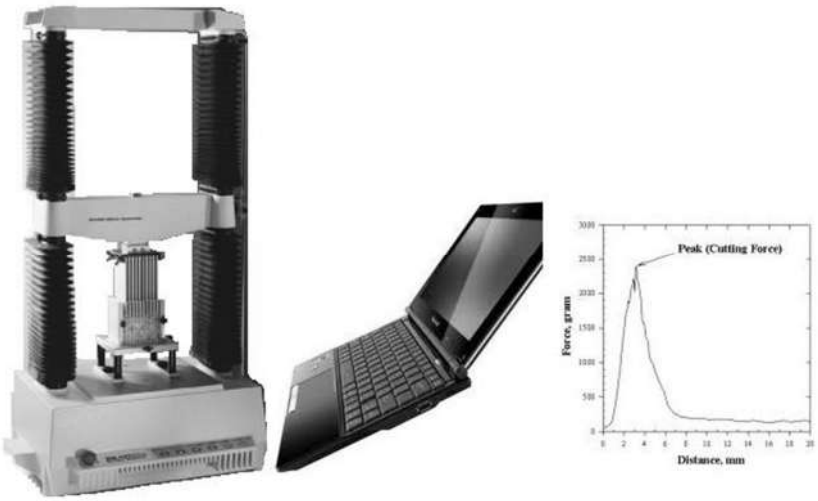


Fig Texture Analyzer (*Source:* Stable Micro Systems, U.K.)

Procedure:

i. Select a suitable range load cell and fit it to the texture analyzer with care.

ii. Fix a puncture needle (in case of puncture), cylindrical (in case of compression) or blade (in case of cutting) probe by screwing it to the load cell.

iii. Put the texture analyzer on by pressing the switch on the button of it.

iv. Put the computer on interfacing with the texture analyser.

v. Now, open the driver software supplied with the texture analyser on the computer and go to T.A. Manu.

vi. Set the essential parameters for the particular test in the respective columns as pre-test speed, test speed, post-test speed, trigger force, probe number, distance, force, time, test mode (puncture, compression, or cutting), force unit and Update Project.

vii. Place a sample on the sample holder (referring to the instructional manual is important as wide manufacturers of Texture analysers are available in the market).

viii. Back to main Menu and go to click on Run a Test.

ix. A real time result of the test will be seen on the computer screen.

x. Interpret the result plotted on the screen in terms of force, distance and time into textural parameters.

xi. Modify the settings and perform for other tests modes (accordingly whether it will be compression, puncture or cutting test).

Skill Set (PFE) 4: Measurement of frictional properties of different grains

Skills to impart: Measurement of frictional property of grain

Tools and materials: Friction table, pulley, thread, wooden frame, grains and force transducer

The frictional properties such as coefficient of friction and angle of repose are important in designing many agricultural processing equipment and storage structures such as hoppers, chutes, pneumatic and screw conveying systems, storage bins, etc. The friction force acting between the surfaces of contact at rest, concerning each other, is called static friction. On the other hand, the friction forces existing between the surfaces in relative motion is called kinetic friction.

If 'F' is the force of friction and 'W' is the force normal to the surfaces of contact, then the coefficient of friction 'f' is given by

$$f = \frac{F}{W}$$

The coefficient of friction may be also defined as the tangent of the angle of the inclined surface upon which the friction force is tangential to the surface and component of the weight normal to the surfaces of acting.

The coefficient of friction can be determined by using a friction table, pulley, thread, and a force transducer as shown in the figure

Materials required:

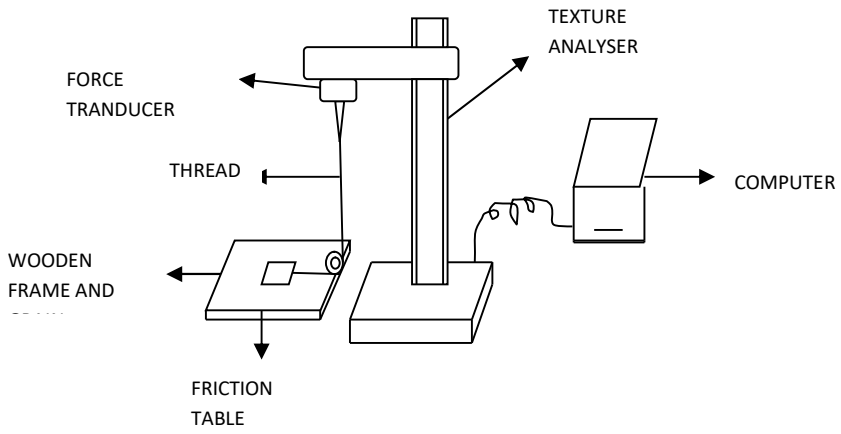


Fig. Friction test set up

Procedure:

i. Place the friction table near the transducer

ii. Fix the thread connecting wooden frame with the probe of the transducer in such a way that the path of the thread up to the pulley of the friction table should be vertical.

iii. Load the wooden frame with grains.

iv. Start the texture analyzer and set the test mode in tension.

v. Set distance, time, speed, and trigger force.

vi. Run the test and measure the total friction force recorded by the instrument.

vii. Remove the grains and take weight a W.

viii. Run a test for empty wooden frame and measure the friction force

ix. The difference between the readings in step vi and viii is the actual friction force of the grains for the particular friction surface as F.

x. Calculate the co-efficient of friction.

Skill Set (PFE) 5 : Operation and performance evaluation of cleaners

Skills to impart : Performance evaluation of grain cleaners

Tools and materials : Vibratory air screen cleaner cum grader

In air screen grain cleaners, the vibratory screens are used in combination with air current for satisfactory performance in cleaning and separation processes. Grading refers to classification of cleaned product into various fractions depending up on their commercial values and usage. These cleaner cum graders are used for granular materials.

Procedure:

- Select screens of suitable size and fit into the cleaner cum grader.
- Take a known weight of uncleaned paddy (feed).
- Feed it into the cleaner cum grader and operate the machine.
- Collect all screen fractions (material from all discharge outlets).
- Measure the weight of collected screen fractions.
- Calculate weight of clean grains by taking the sum of weights of material collected from clean grain outlets.
- Note down the time of operation.
- Calculate the capacity of the machine by dividing the feed weight by time of operation.

Pedal operated air screen cleaner:

In air screen grain cleaners, the screens are used in combination with air current for satisfactory performance in cleaning and separation processes. The performance is assessed using cleaning efficiency

Procedure:

- Take a known weight of uncleaned paddy
- Feed it into the cleaner and operate the cleaner
- Measure the weight of product coming out of different product outlets
- Take samples of uncleaned paddy, cleaned paddy and product from foreign matter outlets
- Measure the amount of cleaned paddy in these samples manually
- Determine the fraction of cleaned paddy in feed (F), foreign matter outlet (G) and clean product outlet (E) and tabulate in the observation table.

- Calculate cleaning efficiency (E_c) using the following formulae

$$E_c = \left[\frac{E(F-G)(E-F)(1-G)}{F(E-G)^2(1-F)}\right] \times 100$$

- Repeat the experiment and determine E_c.

Skill Set (PFE) 6 : Operation and performance evaluation of conveyors and elevators

Skills to impart : Performance evaluation of grain conveyors and elevators

Tools and materials : Working model of belt conveyor, screw conveyor, bucket elevator

Several types of conveyors are widely used for material handling and transport. Belt conveyors are used for horizontal transport of packaged or bulk material whereas bucket elevators are used for vertical conveying of food material. Screw conveyors are used for horizontal and inclined transport of food materials.

CONSTRUCTIONAL DETAILS AND OPERATION

Working models of belt conveyor, screw conveyor and bucket elevator are studied for their salient features and operation. The details are provided below.

Equipment	Constructional details and operation
Belt conveyor	It consists of a flat canvass endless belt moving over two pulleys. One of the pulleys is a driving pulley powered through a motor. A number of idlers are provided to support the belt weight. The operation of the conveyor was observed using packaged food material. During operation, the packaged material was fed from one end of the belt and discharged from the other end. Following observations are to be noted down. Length of the belt, cm: Width of the belt, cm: No. of idlers: Idler spacing, cm: Horizontal conveying distance, m: Motor hp: Belt speed, m/s:
Screw conveyor	It is an inclined-type screw conveyor. It consists of a screw welded to an inclined shaft. The screw is housed inside a cylindrical casing. The screw was driven by a motor. Feed was fed to the conveyor from a hopper at the bottom of the screw. The material was carried up by the screw and was discharged near the top of the screw to a discharge container. The following observations are to be noted down. Motor hp: The angle of inclination of the screw: Screw length, m:

Screw diameter, D (m):

Screw pitch, p (m):

Shaft diameter, d (m):

Inclined conveying distance, m:

The speed of operation, n:..... rps

The capacity of the screw conveyor:

Bucket elevator

It is an inclined-type bucket elevator used for conveying bulk grains in an inclined plane. It consists of several MS buckets attached to an endless belt. The belt moves over two pulleys; the bottom pulley is the driving pulley attached to a motor and the top pulley is the driven pulley. The following observations are to be noted down.

The inclined conveying distance, m:

The angle of inclination:

Motor hp:

No of buckets:

No. of buckets/m length:

The spacing of buckets, m:

The speed of operation. m/s:

The capacity of each bucket, kg:

The theoretical capacity of the bucket elevator, kg/s: bucket capacity x no. of buckets/m length x belt speed =

The actual capacity of the elevator:

Skill Set (PFE) 7 : Operation and performance evaluation of rubber roll sheller

Skills to impart : Performance evaluation of rubber roll sheller

Tools and materials : Rubber roller sheller

Rubber roll shellers are used for shelling paddy i.e. removal of husk from brown rice. It operates on the principle of shear and compression force. These are effective in modern rice milling and widely used due to high milling recovery with less brokens.

CONSTRUCTIONAL DETAILS:

An INDOSAW rubber roll sheller consists of two rolls rotating in opposite directions with a differential speed. One of the rolls is a metal roll and the other roll is a rubber roll. The gap between the rolls can be adjusted for different varieties of grain. This equipment is studied for detailed understanding of the construction and operation of the equipment. The major components, their details and functions of the equipment are enlisted below.

Component	Constructional details	Function
Mainframe and body	Material of Construction/MOC: MS	Support
Feeding hopper with a control mechanism	MOC: MS Feed control mechanism:	For loading and feeding rate control
Dehusking system	No. of rolls: MOC of faster roll: MOC of slower roll: Diameter of rolls: Length of rolls: The gap between the rolls: Speed of Faster Roll: Speed of slower roll: Gap adjustment mechanism:	For grading and cleaning
Driving mechanism	Power operated: _____ hp motor	For rotation of rolls
Power transmission and speed control system	Belt and Pulley mechanism	• For transmission of power from the driving motor to the rolls • For maintaining the differential speed of rolls
Husk separation system	Aspirator	For separation of husk from dehusked rice
Discharge system	Brown rice discharge system: from the bottom of the rolls in trays Husk discharge system: In collection jars connected to an aspirator	For the collection of graded product and foreign materials

Operation: The machine was set to the correct working order and switched on. A known weight of paddy was taken and fed through feeding hopper. The machine was operated to completely dehusk the paddy. After the operation, the brown rice and husk were collected. The weight of brown rice and husk collected were noted down. The machine was switched off. Milling recovery was calculated based on the following formula.

$$Milling\ recovery = \left(\frac{Weight\ of\ brown\ rice}{Weight\ of\ paddy}\right) X100$$

Skill Set (PFE) 8 **: Operation and performance evaluation of rice whitener**

Skills to impart : Performance evaluation of rice whitener

Tools and materials : Rice whitener

Rice polishers/whiteners are used for the whitening of brown rice. In this process, the brown bran layer of rice is removed by friction and abrasion.

CONSTRUCTIONAL DETAILS:

A horizontal-type rice whitener is studied for detail understanding of the construction and operation of the equipment. The major components, their details, and the functions of the equipment are listed below.

Component	Constructional details	Function
Mainframe and body	MS	Support
Feeding hopper	Rectangular	For feeding of brown rice
Abrasive cylinder	An emery roll rotating horizontally on a shaft	For abrasion of bran layer on rice
	Diameter of roll:	
Perforated metal screen	A stationary cylindrical perforated metal screen covers the emery roll with a very fine gap in between	For discharge of bran layer and creating friction on rice
	Diameter of the screen:	
	Spacing between emery roll and meatal screen:	
Rubber brakes	Rubber brakes are placed at uniform intervals on the inside of the perforated metal screen	For creating friction on rice
	No of breaks:	
	Width:	
	Length:	
	Thickness:	
	Spacing of brakes:	

	Spacing between rubber brakes and emery roll:	
Discharge mechanism	An SS blade is provided at the discharge slot on the perforated screen	For controlling the degree of whitening and discharge of whitened rice
Power supply	Motor:	

Operation: The machine was set to the correct working order and switched on. A known weight of brown taken and fed through feeding hopper. The machine opera2-3 minutes minutes. After the operation, the discharge blade was removed, and the white rice was collected. The weight of white rice and bran collected were noted down. The machine was switched off. Product recovery and bran content was calculated based on the following formula.

Product recovery, % = (Ratio of weight of whitened rice to brown rice) X 100

Bran content, % = (Ratio of weight of bran to brown rice) X 100

Skill Set (PFE) 9: Primary processing of horticultural crops

Skills to impart: Primary processing of horticultural produce

Tools and materials: Washer-cum-peeler, potato slicer, slicer, multipurpose cutting machine

Primary processing consists of basic primary operations viz., sorting, washing, peeling, and cutting. These operations are carried out to remove undesirable matter from food products so that the product is ready for further processing.

PROCEDURE:

- Sort the vegetables to remove damaged ones.
- Note down the weight of sorted vegetables.
- Wash the potato washer cum peeler with running water before commencing the process.
- Close the outlet of the machine and fill the potatoes into the machine (potatoes should be 1/3rd of the volume of the machine).
- Close the lid of the machine and switch on the machine.
- Allow the machine to run for 2-3 minutes or until the cover gets removed completely, in the meantime supply water slowly to avoid choking in the machine due to peel.
- After completion of the process, switch off the machine and collect the potatoes in a bucket, rinse it with water twice to remove the peels completely.
- Weigh the washed and peeled potatoes.
- Start the water connection to the washer.
- Load the sorted potatoes into the washer cum peeler.
- Clean the potato slicer using water.
- Keep a bucket to collect the sliced potatoes near the outlet.

- Switch on the machine and load the peeled potatoes slowly into the machine through the inlet.
- Collect the sliced potatoes and take the weight.

Skill Set (PFE) 10: Minimal processing of fruits and vegetables

Skills to impart: Processing of fruits and vegetables

Tools and materials: Ascorbic acid, Calcium chloride, Citric acid, Container, Vegetables, Vegetable cutter, Knife, Washer cum peeler, Basket centrifuge, Hand sealer and shrink wrap machine, Weighing balance, Packaging material: LDPE pouches

Minimal processing consists of basic primary operations viz., sorting, washing, peeling, cutting followed by chemical treatment and packaging to extend the shelf life of cut fruits and vegetables with minimum loss of sensory and nutritional properties. Calcium chloride is used as a firming agent whereas ascorbic acid and citric acid are used as preservatives in minimal processing. The storage life minimally processed vegetables is about 10-14 days under refrigeration.

PROCEDURE/STEPS:

- Sort the vegetables to remove damaged ones.
- Wash and peel the vegetables using washer cum peeler.
- Cut the vegetables (radish, onion, beet, carrot etc.) to slices using vegetable cutter.
- Shred the cabbage using knife.
- Take about 10 litres of water in a container.
- Add 10 g of calcium chloride, 10g ascorbic acid and 10 g citric acid to the water and mix thoroughly.
- Dip the cut vegetables in this water for 3-5 minutes.
- Drain the vegetables.
- Switch on the basket centrifuge and load the vegetables in the basket centrifuge to remove extra water.
- Operate the centrifuge for 5-10 minutes.
- Switch off the machine.
- Unload the vegetables.
- Weigh about 100 g of vegetables and pack it in LDPE pouches.
- Seal the pouches using hand sealer.

Skill Set (PFE) 11: Study of homogenizers

Skills to impart: Use and operation of homogenizers

Tools and materials: Laboratory homogenizer

Homogenization is the operation of size reduction of fat globules to prevent the separation of cream from milk. High-pressure milk is passed through a narrow slit which causes pressure reduction, turbulence, and shearing of milk resulting in the reduction of fat globule size. High-pressure double-stage homogenizer is commonly used to homogenize milk, ice cream mix, fruit juices, etc.

Constructional details:

A high-pressure double-stage homogenizer used for the homogenization of milk and ice cream was studied. It consisted of a triplex plunger pump, homogenizing head, and homogenizer accessories. The details of these components are given below.

Component	Construction	Function
Feeding tank	Made up of SS Capacity: 20 l	For supply of raw milk
Pump	Triplex reciprocating type with a phase shift of 120° Consist of three-cylinder piston arrangement each loaded with suction and discharge valve	For increasing the pressure of milk without any fluctuations
Homogenizing head	All parts made up of SS Consists primarily of outer ring, valve seat and core. Poppet type valve: spring loaded All parts are in two numbers 1st stage head: high pressure (100-200 kg/cm^2) 2nd stage head: low pressure (20-50 kg/cm^2)	For creation of narrow slit and thereby homogenization Homogenization of milk into fine droplets which form clusters For breakage of clusters into separate individual droplets
Homogenizer accessories	Manually operated wheel attached to the spring: 2 numbers Pressure gauge	For adjusting the required homogenizing pressure on the valve. For measurement of homogenizing pressure
Discharge outlet	SS pipe	For discharge of double stage homogenized milk

Operation:

Raw milk is first preheated to around 60°C. The preheated milk is supplied through a feeding hopper. The pressure of this milk increases as it passes through the triplex pump. The 1st stage homogenizing pressure is set to 100 kg/cm^2 using the adjusting wheel and the 2nd stage pressure is set to 50 kg/cm^2. The high-pressure milk enters the 1st stage homogenizing head where it gets homogenized at the set pressure. The 1st stage homogenized milk enters the 2nd homogenizing head where it is re-homogenized at reduced pressure. The homogenized milk is then discharged through the discharge outlet.

Skill Set (PFE) 12 : Operation and performance evaluation of cream separators and butter churns

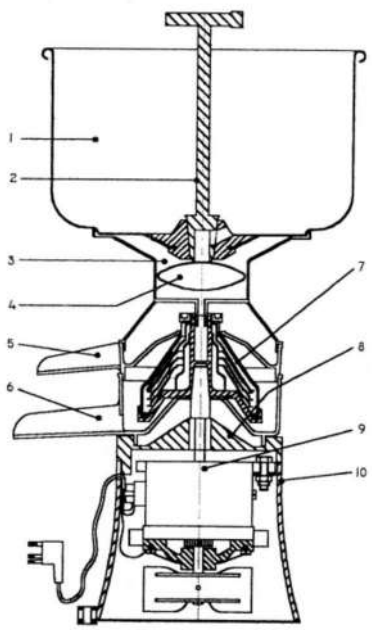
Skills to impart : Operation of cream separators and butter churns

Tools and materials : Milk analyzer, cream separator, and butter churn

Cream separators are widely used for separation of cream from milk. These are based on the principle of centrifugal separation. In these separators, the fat present in milk gets separated due to density difference between fat (lighter phase) and skim milk (heavier phase) and angular acceleration provided through rotation. The velocity of fat during separation can be expressed by the following expression derived from Stoke's law.

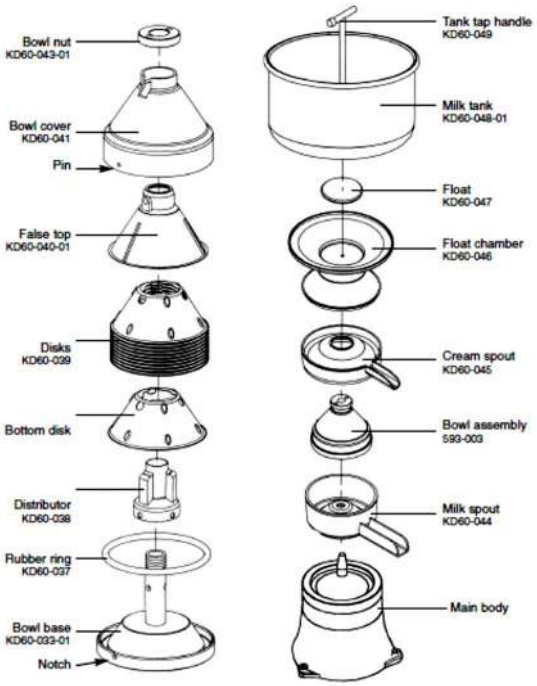
$$v = \frac{d^2(\rho_s - \rho_f)\omega^2 R}{18\mu}$$

Where, d (m) is the diameter of fat globule, ω (rad/s) is the angular velocity, R (m) is the radius of separator bowl, μ (Pa.s) is the viscosity of skim milk, ρ_s and ρ_f (kg/m^3) are the densities of skim milk and fat respectively.



Details of the cream separator

Cream separators are centrifugal separators. The details of the present cream separator are discussed below.



Operation of cream separator:

The bowl and cream separator are assembled. Milk must be strained to remove any dirt or particles. Milk must not be cold, homogenized or sour. Preheat around 4 l of milk to approximately 40°C to ensure all fat to be in liquid condition required for better separation. Preheat the separator by pouring approximately 3.5- 4 l of hot water at 65-66°C into the milk tank. Place containers under the spouts to catch the water. Open the tap and turn the machine on so the hot water flows through the separator and warms all the milk contact parts. Close the tap. Now for separation pour around 4l of warm milk in the tank. Make sure you have in place adequately sized containers to receive the cream and skimmed milk which will come out of the spouts.

Turn the machine on and allow about 1 full minute to let the machine get up to the proper speed. Turn the tap to the "ON" position. Observe the process until all of the milk has passed out of the

milk tank. Let the cream and milk drip for another moment, then remove the containers. Put another container in place to catch the rinse water then immediately pour about 3 l of hot water at 65-66°C into the milk tank. This will clean the last cream from the disks. When the water has run out of the milk tank, turn off the machine and allow the machine to come to a complete stop.

Control of fat content in milk

The cream regulating screw is adjustable and is used to control the fat content in the cream. If it is moved inside or tightened towards the right, a thick cream is obtained and for a left turn, thin cream is obtained. Turn only a quarter of a turn at a time as the setting is very sensitive.

Cleaning, storage and maintenance

After separating your batch of milk, dismantle the spinning bowl and clean all milk contact parts thoroughly using hot water. Dry thoroughly and store in a clean dry place. Proper storage and cleaning is the only regular maintenance required. Inspect and replace any parts that become worn or damaged.

Study of a batch-type butter churn

Background: Butter is a oil water-in-oil emulsion prepared from cream (oil-in-water emulsion) with 35-40% fat. It has a fat content of 80-83% and a moisture content of 12-15%. Butter churn is used for small-scale production of butter. During butter production, the major steps involved are churning and working of cream. In butter churn, both churning and working are carried out in the same place.

Constructional details:

A butter churn mainly consists of a churning cylinder and an adjustable drive. The inside of the cylinder is sand blasted to prevent sticking of butter. It is also fitted with baffles in the inside of the cylinder to effect agitation or uniform churning and working. The other details of the churn are given below.

Component	Construction	Function
Capacity	20 lit	
Churning cylinder	Cylindrical vessel made up of SS Capacity: 20l Length: Diameter:	For churning and working of cream
	Sand blasting on the inside surface	To prevent sticking of butter to walls
	No of SS longitudinal baffles:	Creating agitation during churning
Feeding inlet	SS door on the cylinder Feed volume: 45% of cylinder	For loading of churn with cream of 35-40% fat
Discharge outlet	SS door on the cylinder. The same door is used for feeding and discharge of churned cream	Discharge of churned cream after churning
Drain pipe	SS pipe towards one end of the cylinder	Drainage of buttermilk

Viewing port	Circular glass viewing port on the cylinder	Inspection during operation
Cooling water arrangement	A perforated pipe is provided with a cooling water arrangement Cold water at 7°-10°C is sprayed on the churn during operation	For maintenance of low temperature during churning
Driving mechanism	Electrical motor drive for providing speed during churning and working	To provide power to the churn

Operation:

Cream of 35-40% fat is loaded to fill 45% of churn volume. The door is closed, and the churning is carried out at a desired speed. Cold water at 7-10°C is sprayed continuously on the outside of the churn to control the temperature of cream. Churning is carried out for 30-50 minutes till butter granules are formed. The butter milk is then drained out by the drainpipe. The butter granules are then washed twice with water with a quantity of water equal to the quantity of cream followed by rinsing of butter granules with water. The wash water is then drained. The butter is then worked for 30-50 minutes to remove the extra water. The salt is added during work. After the desired working time butter is unloaded in butter trolleys for packaging.

Skill Set (PFE) 13: Study of milk spray dryers

Skills to impart: Use and operation of milk spray dryer

Tools and materials: Laboratory spray dryer

Spray drying is widely used for the production of spray-dried food powders from liquid food using hot air as the heating medium. Hot air in the range of 150 – 200°C is used in spray drying. The product is atomized into fine droplets increasing the surface area. Due to increased surface area, the product gets dried within 4-20 seconds. The product quality is superior in terms of color, flavor retention, and solubility to any other type of high temperature dried product.

Constructional details:

The details of the spray dryer are given below.

Operating conditions	
Capacity	1 kg of water/h evaporation rate
Feed rate	15-20 ml/min
Feeding temperature	Ambient to 70°C
Product moisture content, % wb	
Hot air inlet temp.	180 - 200°C for milk
Outlet air temp.	90°C for milk
Product temp.	< 60°C

Component	Construction	Function
Feed tank	SS 304	For storage of feed
Feed pump	Peristaltic pump	For supply of feed
Atomizer	Pneumatic atomization	Atomization of feed
Inlet Air supply	Centrifugal blower	Supply of inlet air
Air heating	Direct electrical heating with heater	Heating of drying air
	Heater capacity:	
	Hot air supply through SS 304 pipes	
Spray/drying chamber	Shape:	Drying of milk
	Material of construction:	
	Dimensions:	
	Draw figure	
Cyclone separator	Material of construction:	Recovery of very fine powders entrained with outlet air
	Diameter of cyclone:	
	Other dimensions:	
Powder collection bin	Material of construction:	Collection of spray-dried milk powder
Accessories	Temperature sensors	To control the operation of spray dryer
	Control panel	

FARM MACHINERY AND POWER ENGINEERING (FMPE)

Skill Set (FMPE) 1: Operation, adjustment, and maintenance of lathe machines

Skills to impart: To learn operation and adjustments pf lathe machine

Tools and materials: Production lathe machine

Introduction

A lathe is a machine tool that rotates a work-piece about an axis of rotation to perform various operations such as *cutting, sanding, knurling, drilling, deformation, facing, threading,* and *turning*, with tools that are applied to the work-piece to create an object with symmetry about that axis. It is generally used to shape metallic products. It furnishes a wooden or metal piece by rotating it about an axis while a stationary cutting tool keeps removing unwanted material from the work-piece to form the desired shape

Machine description

i. The purpose of a metal lathe is to face, turn, knurl, thread, bore, or cut tapers in a metal workpiece with perfect accuracy.

ii. During typical operations, the lathe spindle rotates the workpiece at various speeds against a fixed cutting tool that is positioned at a particular angle for the desired type of cut.

iii. The cutting tool is mounted on a tool post, which is positioned by three different slides that each move in different directions.

iv. Opposite of the headstock and spindle is a support device called a tailstock. The tailstock can be slid along the lathe bed and locked in place to firmly support the end of a workpiece.

Additional safety/adjustment for metal lathes

i. **Speed rates.** Operating the lathe at the wrong speed can cause nearby parts to break or the workpiece to come loose, which will result in dangerous projectiles that could cause severe impact injuries. Large or non-concentric workpieces must be turned at slow speeds. Always use the appropriate feed and speed rates.

ii. **Chuck Key safety.** A chuck key left in the chuck can become a deadly projectile when the spindle is started. Always remove the chuck key after using it. Develop a habit of not taking your hand off of a chuck key unless it is away from the chuck.

iii. **Safe clearances.** Workpieces that crash into other components on the lathe may throw dangerous projectiles in all directions, leading to impact injury and damaged equipment. Before starting the spindle, make sure the workpiece has adequate clearance by hand-rotating it through its entire range of motion. Also, check the tool and tool post clearance, chuck clearance, and saddle clearance.

iv. **Long stock safety.** Long stock can whip violently if not properly supported, causing serious impact injury and damage to the lathe. reduce this risk by supporting any stock that extends from the chuck/headstock more than three times its own diameter. Always turn long stock at slow speeds.

v. **Securing Workpiece.** An improperly secured workpiece can fly off the lathe spindle with deadly force; which can result in a severe impact injury. Make sure the workpiece is properly secured in the chuck or faceplate before starting the lathe.

vi. **Chucks.** Chucks are heavy and difficult to grasp, which can lead to crushed fingers or hands if mishandled. Get assistance when handling Chuck to reduce this risk. protect your hands and the precision-ground ways by using a chuck cradle or piece of plywood over the ways of the lathe when servicing chucks. Use lifting devices when necessary.

vii. **Clearing chips.** Metal chips can easily cut bare skin—even through a piece of cloth. Avoid clearing chips by hand or with a rag. Use a brush or vacuum to clean metal chips.

viii. **Stopping spindle by hand.** Stopping the spindle by putting your hand on the work piece or chuck creates an extreme risk of entanglement, impact, crushing, friction, or cutting hazards. Never attempt to slow or stop the lathe spindle with your hand. Allow the spindle to come to a stop on its own or use the brake.

ix. **Crashes.** Aggressively driving the cutting tool or other lathe components into the chuck may cause an explosion of metal fragments, which can result in severe impact injuries and major damage to the lathe. Not leaving the lathe unattended and checking clearances before starting the lathe. Make sure no part of the tool, tool holder, compound rest, cross slide, or carriage will contact the chuck during operation.

x. **Coolant safety.** Coolant is a very poisonous biohazard that can cause personal injury from skin contact alone. Incorrectly positioned coolant nozzles can splash on the operator or the floor, resulting in an exposure or slipping hazard. To decrease your risk, change coolant regularly and position the nozzle where it will not splash or end up on the floor.

xi. **Tool selection.** Cutting with an incorrect or dull tool increases the risk of accidental injury due to the extra force required for the operation, which increases the risk of breaking or dislodging components that can cause small shards of metal to become dangerous projectiles. Always select the right cutter for the job and make sure it is sharp. A correct, sharp tool decreases strain and provides a better finish.

Additional chuck safety

i. **Entanglement.** Entanglement with a rotating chuck can lead to death, amputation, broken bones, or other serious injury. Never attempt to slow or stop the lathe chuck by hand, and always roll up long sleeves, tie back long hair, and remove any jewellery or loose apparel before operating.

ii. **Chuck speed rating.** Excessive spindle speeds greatly increase the risk of the work piece or chuck being thrown from the machine with deadly force. Never use spindle speeds faster than the chuck RPM rating or the safe limits of your work piece.

iii. **Using correct equipment.** Many work pieces can only be safely turned in a lathe if additional support equipment, such as a tailstock or steady/follow rest, is used. If the operation is too hazardous to be completed with the lathe or existing equipment, the operator must have enough experience to know when to use a different machine or find a safer way.

iv. **Trained operators only**. Using a chuck incorrect can result in work pieces coming loose at high speeds and striking the operator or bystanders with deadly force. To reduce the risk of this hazard, read and understand this document and seek additional training from an experienced chuck user before using a chuck.

v. **Chuck capacity.** Avoid exceeding the capacity of the chuck by clamping an oversized workpiece. If the workpiece is too large to safely clamp with the chuck, use a face plate or a large chuck if possible. Otherwise, the workpiece could be thrown from the lathe during operation, resulting in serious impact injury or death.

vi. **Clamping force.** Inadequate clamping force can lead to the workpiece being thrown from the chuck and striking the operator or bystanders. Maximum clamping force is achieved when the chuck is properly maintained and lubricated, all jaws are fully engaged with the workpiece, and the maximum chuck clamping diameter is not exceeded.

vii. **Proper maintenance.** All chucks must be properly maintained and lubricated to achieve maximum clamping force and withstand the rigors of centrifugal force. To reduce the risk of a thrown workpiece, follow all maintenance intervals and instructions in this document.

viii. **Disconnect power.** Serious entanglement or impact injuries could occur if the lathe is started while you are adjusting, servicing, or installing the chuck. Always disconnect the lathe from power before performing these procedures.

OPERATION

This overview is the basic process that occurs when operating this machine. Familiarize yourself with these steps to better understand the remaining parts of the operation section.

i. Put on safety glasses, roll up sleeves, remove jewelry, and secure any clothing, jewelry, or hair that could get entangled in moving parts.

ii. Examine the workpiece to make sure it is suitable for turning, and then mount the workpiece required for the operation.

iii. Mount the tooling, align it with the workpiece, and then adjust it for a safe startup clearance.

iv. Clear all tools from the lathe.

v. Set the correct spindle speed for the operation.

vi. Check for safe clearances by rotating the workpiece by hand one full revolution.

vii. Move slides to where they will be used during operation. If using a power feed, select the proper feed rate for the operation.

viii. Turn the main power switch ON, reset the stop button so it pops out, then move the spindle ON/OFF lever to start spindle rotation. The spindle will rotate forward (the top of the chuck rotates toward the operator).

ix. Use the carriage hand-wheels or power feed options to move the tooling into the workpiece for operations.

x. When finished cutting, move the ON/OFF lever to the center position to turn the lathe OFF then remove the workpiece.

Apron controls

Use the descriptions in this section and the controls to quickly understand the functions of the apron and its related controls. Spindle ON/OFF Lever

Starts and stops the spindle in forward and reverse.

- Moving the lever upward from the central OFF position spins the chuck forward (the top of the chuck moves toward the machinist).

- Moving the lever downward from the central position spins the chuck in reverse (the top of the chuck moves away from the machinist).

Feed Selection Lever: Allows the machinist to engage or disengage the apron for longitudinal or cross-feeding tasks.

Carriage Lock Lever: Clamps the right front of the saddle to the lathe way for increased rigidity when facing a workpiece.

Half-Nut Lever: Clamps the half-nut to the lead screw for threading operations.

Thread Dial: Avoids cross-cutting threads by indicating to the machinist where to re-clamp the half nut to resume threading after a carriagreturnsrn.

Carriage Handwheel: For moving the carriage longitudinally left or right along the ways.

Cross Slide Handwheel: Moves the cross slide in or out perpendicular to carriage travel and is equipped with a standard Dial.

Compound Slide Hand wheel: Moves the compound and cutting tool relative to the workpiece at various angles with fine-depth control.

Compound Slide Scale: The 90° rosette on the top of the compound indicates compound angles. Zero splits the scale into two ranges, 45° to the right and 45° to the left in 1°-degree increments.

Quill Lock Lever: Secures the quill in a locked or pre-loaded position.

Tailstock Lock Lever: Clamps the tailstock in place for general position locking along the lathe bed.

Set screw: Allows the tailstock to be locked in place using a wrench to control amount of drawdown alignment with the spindle centerline.

Tailstock Hand-wheel: Advances or retracts the quill in the tailstock at a 1:1 ratio with the micrometer scale on the hand-wheel hub.

Brake: This lathe is equipped with a foot brake to quickly stop the spindle. Pushing the foot brake while the spindle is ON cuts power to the motor and stops the spindle. Once stopped, the spindle ON/OFF lever MUST be returned to the neutral position before the spindle can be restarted.

Chuck & faceplate removal/installation

This lathe may be with a 3-jaw chuck installed, but some time you need to use a 4-jaw chuck or faceplate. The chucks and faceplate mount to the spindle with a camlock system, which uses a key to loosen and tighten camlocks for removal or installation

Before the 4-jaw chuck and faceplate can be installed on the spindle, their respective cam studs must be installed and adjusted. To maintain consistent removal and installation of the chucks and faceplate, each should have a timing mark that can be lined up with a matching one on the spindle, so it will be installed in the same position every time). Before removing the 3-jaw chuck, verify that a timing mark exists. If a mark cannot be found, stamp your own on both the chuck and spindle.

Chuck & faceplate removal

i. Disconnect lathe from power.

ii. Lay a chuck cradle or a layer of plywood over the bed ways to protect the precision ground surfaces from damage and to prevent fingers from being pinched.

iii. Loosen the cam-locks by turning the key counterclockwise approximately one-third of a turn until the mark on the cam-lock aligns with the single mark on the spindle nose in. If the cam-lock stud does not freely release from the cam-lock, wiggle the cam-lock until the cam-lock stud releases.

Chuck & faceplate installation

i. Disconnect lathe Form power!

ii. Place a piece of plywood across the lathe ways just under the chuck, and use a chuck cradle if desired.

iii. Make sure the chuck taper and spindle taper mating surfaces are perfectly clean.

iv. Inspect and make sure that all camlock studs are undamaged, are clean and lightly oiled, and that the camlock stud cap screws are in place and snug.

v. Align the chuck-to-spindle timing marks and slide the chuck onto the spindle.

vi. Turn a camlock with the chuck wrench until the cam mark falls between the "v" marks. If the cam lock mark stops outside of the “v” marks, remove the chuck and adjust the cam stud height of the offending studs one full turn up or down.

vii. Lock the other cams in a star pattern so the chuck is drawn up evenly on all sides without any chance of misalignment.

viii. Remove the chuck wrench.

Mounting work piece

a. Disconnect the lathe from power.

b. Lay a piece of plywood on the bedway underneath the spindle to protect the precision ground surfaces.

c. Insert the chuck key into a scroll keyway and rotate it counterclockwise to open the jaws until the workpiece sits flat against the chuck face, evenly on the jaw steps, or fits into the chuck hole and through the spindle bore.

d. Close the jaws until they make light contact with the workpiece.

e. Turn the chuck by hand to make sure the workpiece is evenly held by all three jaws and is centered on the chuck. If the workpiece is not centered, loosen the jaws and adjust the work piece, then re-tighten the jaws and repeat step5 if the workpiece is centered, fully tighten the jaws.

Removing jaws

i. Disconnect the lathe from power.

ii. Place a piece of plywood on the bed way to protect it, then remove the chuck from the lathe.

iii. Lay the chuck on a flat, stable surface, then insert the chuck key into a scroll keyway and rotate it counterclockwise to back the jaws all the way out of the jaw guides.

iv. Thoroughly clean the jaws with shop rags and mineral spirits, then apply a thin coat of an anti-rust protective lubricant before storing them in a protected location free from moisture and abrasives.

Installing jaws

a. Place the chuck on a flat, stable surface.

b. Examine the side of the jaws-each is stamped with a number 1 through

c. Examine the jaw guides of the chuck-each is stamped with a corresponding number

d. Insert the chuck key into a scroll keyway and rotate it until you see the beginning of the scroll gear's lead thread come into view through the #1 jaw guide, then back it off slightly until it disappears

e. Slide the #1 jaw into the #1 jaw guide and hold it firmly against the scroll gear threads, then rotate the chuck key clockwise approximately one turn until the lead thread engages with the jaw.

f. Rotate the chuck key clockwise to bring the jaws together in the center of the chuck.

g. If installed correctly, the jaws will converge evenly at the center of the chuck. If the jaws do not come together evenly, remove them, make sure the numbers of the jaws and the jaw guides match, then properly re-install them.

Centers

Sometimes you need to use dead centers, live center, and adapter sleeves to adapt the centers into the spindle bore. When installing centers verify that all mating surfaces are clean and free of nicks and burrs.

Solid dead center

Dead centers are typically used in low-speed turning operations to increase rigidity for close tolerances. The solid dead center is installed at the spindle end of the lathe because the workpiece, center, and spindle all turn together by the use of a lathe dog. One end of the lathe dog is clamped to the workpiece, and the other end the tail, is inserted into a faceplate slot shown.

Carbide-tipped dead center

When the workpiece is supported at the tailstock end of the lathe, the workpiece will spin on the tip of the fixed center. To eliminate the tip of the center from wearing out at this point of contact, the carbide-tipped center is used. Nevertheless, during turning operations this tip must still be lubricated vigilantly, or the workpiece will wear, resulting in increased end play and poor turning results. Typically, when using centers, the tailstock quill should be locked and protruded, but not too long.

Live center

If the workpiece must be spun at higher speeds, the live center is inserted into the tailstock. Unlike a dead center, the tip of the live center is supported with precision bearings that allow it to support and spin with the workpiece. As a result, virtually no wear occurs, and the workpiece can be turned with less concern about developing end play from tip wear. However, when using live centers, accuracy can suffer as a result of having bearings support the end of the workpiece.

Installing center in Tailstock

- Center drills the end of the workpiece to be turned or threaded.
- Feed the quill out about 25mm (1"), wipe clean and insert the center into the quill bore (To help prevent wear, place a dab of grease on the point of the center.
- Position the tailstock so the center presses against the workpiece, then lock the tailstock in place.

- Preload the quill into the workpiece. The force against the workpiece will fully seat the tapered center.
- Lock the quill into place. However, keep in mind that the quill may need to be adjusted during operation to remove any play that develops between the center and the workpiece.

Removing center from tailstock

To remove the center, hold the end of the center with a rag to prevent it from falling, and reverse the handwheel until the center is pressed free.

- Installing center in spindle
- Install the dead center into the spindle sleeve.
- Install the sleeve into the spindle bore.
- Determine whether to use the chuck or faceplate and install the required unit.
- Clamp the required lathe dog onto the workpiece and mount the workpiece between the lathe centers.

Removing center from spindle

To remove a center and sleeve, hold the end of the center with a rag to prevent it from falling, insert a wooden rod into the outboard side of the spindle, and tap the center and sleeve free.

To load a tool holder:

- Install the required cutting tool in the tool holder.
- Move the quick-change lever to recess the lock piston and provide an unobstructed slot for the tool holder to slide down into.
- Slide the tool holder into position and tighten the quick-change lever.
- Use the handwheels to bring the tool to the required position.
- Double-check that tool angle, height, and position are correct.
- Make sure that all fasteners related to the tool, holder, and tool post are tight.

Feed settings

Various feed rates are achieved on this lathe by moving knobs, levers, and rearranging change gears according to the threading chart located on the headstock.

To set up for a power feed operation:

- Disconnect lathe from power!
- Open the change gear's door on the left-hand side of the headstock to expose the change gears.
- look at the lathe feed rate chart and find the required feed rate for your turning or facing operation. If for example, a carriage feed rate of 0.083mm is needed, the change gears and feed dials must be in the following positions:
- The quick-change gearbox there are four knobs, turn the first knob to "4" position, turn the second knob to "S" position, turn the third knob to "C" position and turn the fourth knob to "I" position. Leaving 0.08mm–0.15mm backlash between gear teeth, arranges the 24 teeth change gear to 120 teeth and 120 teeth to 48 tooth change gear.
- Rotate the spindle by hand to verify no binding exists and close the gear door.
- When lever is positioned to the right side, the carriage will move to the left along the bed, or the cross feed will travel toward the front of the lathe.

Feed selection lever

To prevent apron and drive system damage, the apron is equipped with an internal lockout, meaning that in order to engage the half nut for threading, this lever must be moved to the central or the disengaged position. Also keep in mind that just as with longitudinal feed operations, before any threading operation. You must first verify the carriage lock is disengaged, or the feed system may be damaged.

Cleaning

Cleaning the lathe is relatively easy. Disconnect the lathe before cleaning it. Remove chips as they accumulate. Vacuum excess metal chips and wipe off the remaining cutting fluid with a dry cloth when finished for the day. Chips left on the machine soaked with water-based cutting fluid will invite oxidation and gummy residue to build up around moving parts. Preventative measures like these will help keep your lathe running smoothly. Always be safe and responsible with the use and disposal of cleaning products.

Skill Set (FMPE) 2 : Operation, adjustment and maintenance of different types of welding machines

Skills to impart : To learn different welding machines and their working

Tools and materials : Electric arc welding machine, Gas welding machine, MIG welding

INTRODUCTION

Welding is a process of joining similar or dissimilar metals by application of heat with or without application of pressure and addition of filler material. Now-a-days many processes of welding have been developed and probably there is no industry which is not using welding process in the fabrication of its products in some form or the other. This is the most rapid and easiest way of fabrication and assembly of metal parts. The research carried out in this field has given various ways and methods to weld practically all metals. Means have also been found out to weld dissimilar metals. One beauty of welding in comparison to other processes of joining metals is that by this process we can have more than 100% strength of joint and it is very easy process. We shall be dealing with the various processes of welding in use these days, the equipment used for each process and the ways of preparation of joint and the Various operations necessary.

TYPES OF WELDING PROCESSES

1. Gas welding
    - Oxy acetylene
    - Air-acetylene
    - Oxy-hydrogen
2. Arc welding
    - Carbon arc welding
    - Metal arc welding
    - Gas metal arc welding

- Plasma arc welding
- Electro-slag welding
- Gas tungsten arc welding
- Submerged arc welding
- Flux-cored arc welding
- Atomic-hydrogen arc welding

3. Resistance welding
    - Butt welding
    - Projection welding
    - Spot welding
    - Percussion welding
    - Seam welding
4. Thermit welding
5. Solid state welding
    - Friction welding
    - Ultrasonic welding
    - Diffusion welding
    - Explosive welding
6. Advanced welding technique
    - Electron beam welding
    - Laser beam welding

MATERIALS THAT CAN BE WELDED

The term "weldability" has been defined as the capacity of being welded into inseparable joints having specified properties such as definite weld strength, proper structure, etc. This means, of course, that if a particular metal is to have good weldability, it must be welded readily so as to perform satisfactorily in the fabricated structure. Weldability depends on one or more of five major factors:

- Melting point
- Thermal conductivity
- Thermal expansion
- Surface condition
- Change in microstructure.

Common materials that can be welded using various welding techniques are wrought iron, mild steel, medium carbon steel, high carbon steel, cast steel, stainless steel, tool steel, alloys steel, cast iron, aluminum, copper and its alloys, nickel and nickel alloys, etc.

TUNGSTEN INERT GAS (TIG) WELDING

Tungsten inert gas (TIG) welding is one of the cleanest processes. In this process filler metal is supplied from a filler wire. As the tungsten electrode is not consumed in this operation, a constant and stable arc gap is maintained at a constant current level. The filler metals are similar to the metals to be welded, and flux is not used. The shielding gas is usually argon or helium (or a mixture of the two). Welding with GTAW may be done without filler metals—for example, in the welding of close-fit joints.

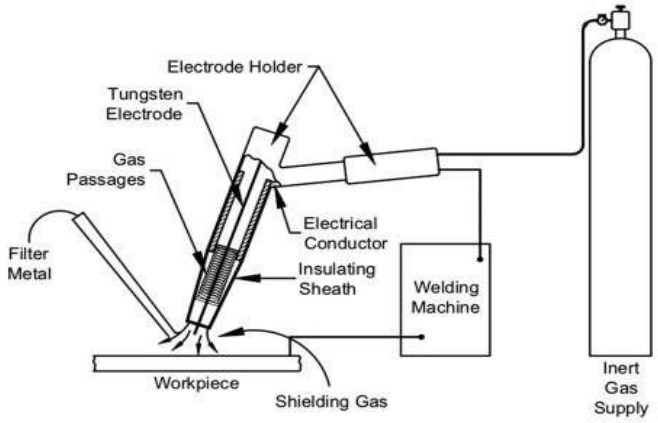


Fig. Components of TIG welding

Procedure:

- First fix the job pieces in the fixture securely.
- Turn on the gas supply and adjust the flowrate using the regulator and flow meter.
- Now press the gas flow checking button on the machine to ensure inert gas supply to the torch.
- Next the tungsten electrode has to be fitted in the torch. The torch assembly layout is as follows.
- Now set the welding current from the machine.
- Check the electrical connections and AC/DC selection.
- After checking everything hold the torch and electrode in proper position. Pull the button on the torch to and hold it continue welding

SUBMERGED ARC WELDING

Submerged Arc Welding (SAW) is a fully automated high productive process. A bare electrode is continuously fed through contact tube connected to the power source. Wire feeding is done by a motor connected with the controller. The arc is generated when the electrode comes closer to the job piece.

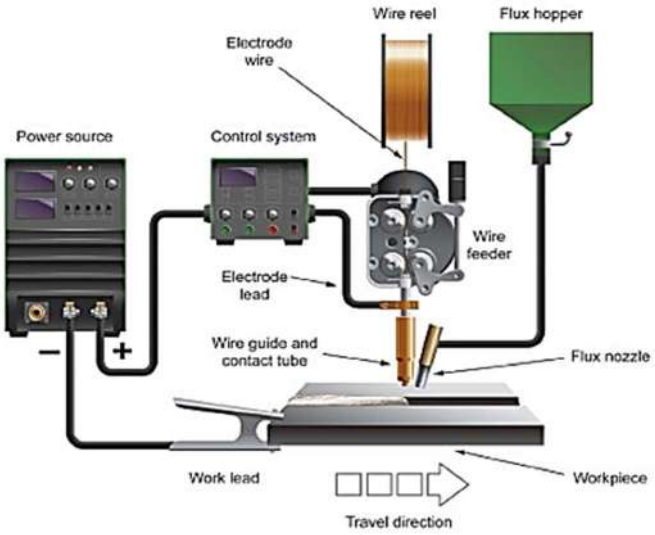


Fig. Components of submerged arc welding

The power supplies usually are connected to standard single- or three-phase power lines with a primary rating up to 440 V. Because the flux is gravity fed, the SAW process is limited largely to welds in a flat or horizontal position having a backup piece. Circular welds can be made on pipes and cylinders—provided that they are rotated during welding.

Procedure

- First check the power connections and polarity.
- Fill the flux hoper with granular flux and check continuity of flux flow by opening the stopper.
- Fit the electrode wire through the drive and guide roller.
- Turn on the power and check travel and wire feed as well as mark the welding line.
- Clamp the two pieces to be welded along the weld line.
- Now set operating parameters on the control panel.
- Release the flux stopper to cover the plates and electrode with fluxes.
- Engage the auto travel lever and start the process.
- Check for the sound of welding as a signal that welding is going on.
- After completion of travel turn off the process from the controller and close the flux stopper.
- Collect the unused flux and then remove the solidified slag by chipping.
- Unclamp the job after cooling and extract test pieces by cutting it for mechanical and metallurgical testing.

ELECTRIC ARC WELDING

Arc welding is the most extensively employed method of joining metal parts. Here the source of heat is an electric arc. The arc column is generated between an anode, which is the positive pole of dc (direct current) power supply, and the cathode, the negative pole. When these two conductors of an electric circuit are brought together and separated for a small distance (2 to 4 mm) such that the current continues to flow through a path of ionized particles (gaseous medium), called plasma, an electric arc is formed. This ionized gas column acts as a high- resistance conductor that enables more ions to flow from the anode to the cathode.

Arc Welding Equipment:

1. A.C or D.C machine
2. Electrode
3. Electrode holder
4. Cables, cable connectors
5. Cable jug
6. Chipping hammer
7. Earthing clamps
8. Wire brush
9. Helmet
10. Safety goggles
11. Hand gloves
12. Apron, sleeves etc.

Welding cables: welding cable is used to connect the job with the earth line and the electrode holder with the main line (phase line). Two welding cables are required, one from the machine to the electrode holder and the other from the machine to the Earthing clamp or to the work piece.

Electrodes: Both non consumable and consumable electrodes are used for arc welding. Non consumable electrodes may be made of carbon, graphite or tungsten which do not get consumed during the welding operation. Consumable electrodes may be made of various metals depending upon their purpose and the chemical composition of the metals to be welded.

Electrode holder: It consists of a handle and jaw. The electrode holder is connected to the end of the welding cable and holds the electrode. It should be light, strong and easy to handle and should not become hot while in operation. The jaws of the holder are insulated.

Earthing clamp: It is connected to the end of the work cable and is clamped to the workpiece or welding table to complete the electric circuit. It should be Strong and durable and have a low resistance.

Wire brush and chipping hammer: A wire brush is used for cleaning and preparing the work for welding. A chipping hammer is used for removing slag formed on welds. One end of the head is sharpened like a cold chisel and the other, to a blunt, round point. It is generally made of tool steel.

Applications of arc welding

- Aerospace and aircraft construction
- Automotive industry
- Auto body repairs
- Used for most types of sheet metal welding
- Fabrication of pressure vessels and steel structures
- Shipbuilding
- Construction industries, etc.

Skill Set (FMPE) 3: Operation, adjustment, and maintenance of different ploughs

Skills to impart: To learn construction, working, and adjustments of ploughs

Tools and materials: MB Plough, Disc Plough

Ploughing or tillage is the first operation in farming, which is defined as the mechanical manipulation of soil to create favorable soil conditions for sowing. The first major soil-cutting operation is known as primary tillage and the subsequent finer soil working operations done to prepare a fine seedbed for sowing are known as secondary tillage. Primary tillage implements are heavier than secondary tillage implements. Primary tillage implements include mould board plough, disc plough, and sub-soiler.

Mould board plough

Constructional Features

Mould board plough parts can be grouped into two major groups viz., plough bottom and plough accessories.

Plough Bottom

The plough bottom is the main working body of the plough. The bottom consists of different parts like share, mould board, landside, and frog as shown in the following figure.

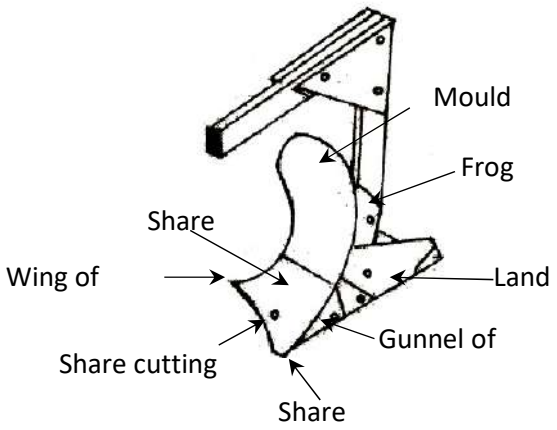


Fig. Mould board plough showing different parts

Materials of construction of Mould Board plough parts

Name of the part	Material	
	Animal drawn	**Tractor drawn**
Beam	Wood/mild steel	Forged steel
Handle	Wood/mild steel	-
Standard	Cast iron/mild steel	-
Share	Chilled cast iron	Chilled cast iron/high carbon steel

Mould board	Chilled cast iron/mild steel	Soft centre steel/ Chilled cast iron/crucible steel
Landside	Cast iron/mild steel	Cast iron/mild steel
Frog	Cast iron/mild steel	Cast iron/mild steel
Braces	Mild steel	Mild steel
Gauge wheel	Cast iron	Cast iron
Furrow wheel	Cast iron/mild steel	Cast iron/mild steel

Mould board plough measurements and adjustments

Plough size: The plough bottom size is the width of the furrow that it is designed to cut. It is measured as the horizontal distance between the wing of the share and the landside. In tractor-drawn ploughs, 30, 35, and 40 cm plough bottoms are most commonly used. In multi-bottom ploughs the rated width, or the working width of the plough is expressed as the product of a number of bottoms and the size of one bottom.

***Vertical or down suction*:** This is the amount by which the share point of the plough is bent downward to help the plough penetrate the soil to the proper depth when the plough is pulled forward. It is measured as the maximum distance between the landside and ground surface when the plough is kept in normal working position over a leveled ground. Usually, it is kept at 3 to 5 mm.

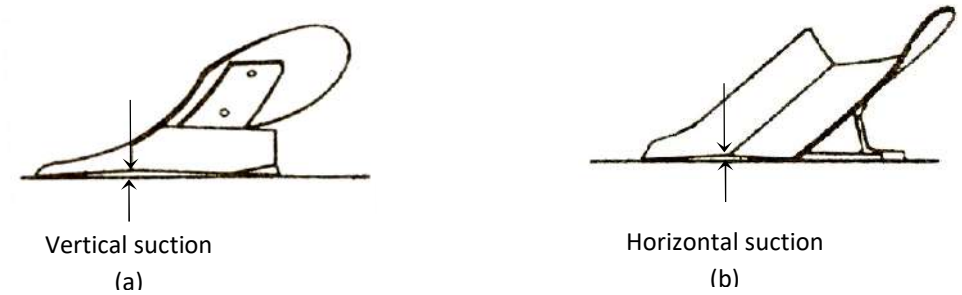


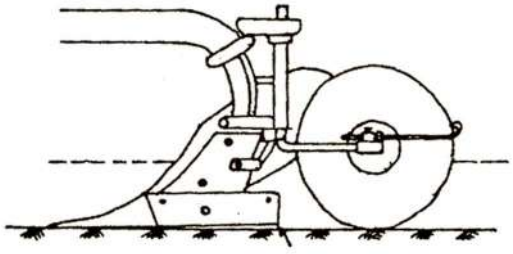
Fig. Suctions (clearances) in mould board plough

Horizontal or side suction: this is the amount by which the point of the share is bent off-line with the landside. It can be measured by placing a scale on the side of the plough extending from the heel of the landside to the point of share. It is usually kept at 5 mm. This suction helps the plough to take the proper width of cut.

***Heel clearance and Landside clearance*:**

In plough with rear furrow wheel, the heel of landside must be 8 – 12 mm above the bottom of the furrow so that the rear furrow wheel carries one third of the plough weight. This clearance is known as heel clearance. The landside should be adjusted in such a manner that there is a clearance of 12 – 20 mm between furrow wall and rear of the landside.

***Coulter and jointer setting*:** To obtain a neat furrow wall, the coulter is usually set 2 cm outside the



landside of the plough. For average ploughing, coulter should be directly over the share point and cut half the depth of ploughing. The jointer should be set to cut 4 – 5 cm deep. It should be placed as near the coulter as possible.

***Plough leveling*:** The fore and aft leveling of the plough can be done by adjustment of the top link length. If the front plough bottom goes deeper than the rear one than top link is lengthen and it is shortened if the rear bottom goes deeper than the front one. The lateral leveling can be done by adjusting the right lower link length to make the plough frame parallel to ground.

Furrow wheel setting: the width of cut of front bottom can be adjusted by changing the position of furrow wheel. It is also adjusted to adjust the landside clearances.

DISC PLOUGH

The disc plough is an implement where the cutting and inversion of soil are performed using discs. This was introduced to reduce friction by making a rolling bottom instead of a bottom that would slide along. Disc plough creates no suction but depends on weight and disc angle for penetration, therefore they are heavily built. Disc plough must be operated at a fairly slow, uniform speed for best cutting action and width of cut control. The disc plough usage shows that it is adapted to conditions where the mould board plough will not work.

Adjustments: To get better results, the following adjustments are necessary:

1. **Cutting Angle Adjustments**: Discs would not cut if they are rolled straight ahead. They must be set at an angle. Provision is made in the plough standard for adjustment of the horizontal disc angle and vertical tilt angle to obtain optimum disc operations in different soil conditions.

   (a) Disc angle is the angle which the plain of the cutting edge makes with the line of travel. It is normally $42^0 – 45^0$. Reducing the angle increases disk rotation with respect to ground speed and reduces the tendency of the plough to overcut. Increasing the disc angle improves disc penetration.

   (b) Tilt angle is the angle which the plane of cutting edge makes with the vertical line. It ranges from 15^o-25^0. Increasing the tilt angle improves disc penetration in heavy, sticky soils. Decreasing the tilt angle improves disc penetration in loose and brittle soils. Setting disc in the steeper position puts soil pressure on the disc resulting in faster disc rotation, greater soil pulverization and better covering and coverage of thrash.

2. **Width of cut adjustment**: Every disc plough has a particular width of cut ranging from 18-25cm, which depends on the diameter of the blade. However, to suit various draft and penetration requirements the width of cut for the front disc can be adjusted to a few cms. By rotating the cross shaft and lateral positioning of the furrow wheel.

3. **Leveling the plough**: Most mounted ploughs are designed for the frame to run parallel to the ground, both fore-and-aft and laterally. The fore-and-aft level of the plough is controlled by the tractor top link. If the rear end of the plough beam is higher than the front end of the beam, lengthen the top link and vice versa. Lateral levelling is controlled by adjusting the length of tractor right lower link. These adjustments must be made with plough in operating position.

4. **Scraper adjustment**: Scrapers are set low enough to catch and turn the furrow slice before it falls away from the disc. They are set about $1/8^{th}$ inch away from the centre of the disc and about ¼” away from the centre of the outer edge of the disc.

5. **Furrow wheel adjustment**: The furrow wheel has following adjustments

    a. **Furrow wheel spring tension adjustments:** There is an adjusting screw with a lock nut. The screw when tightened over the spring cap compresses the spring and when slackened releases the pressure. Screwing down the adjusting screw puts more pressure on the furrow wheel and allows the blade to bite into the soil more firmly and vice versa. By adjusting the spring pressure, it either permits or restricts the amount of upward travel of the furrow wheel from the ground. This determines the amount of the plough weight that is carried on the furrow wheel. In wet or loose soil the spring pressure is increased in the furrow wheel to carry more weight, to prevent side movement of the plough. In hard soil, the pressure on the spring may be decreased to transfer weight to the plough disc to increase penetration.

    b. **Furrow wheel lateral adjustment**: The furrow wheel can be adjusted laterally to increase or decrease the width of the cut of the front disc. In general, moving the wheel to the left will decrease the cut of the front disc and the side draft and vice versa.

    c. **Furrow wheel lead angle adjustment**: If the plough tends to swing towards the unploughed land, increase the lead angle but if the plough swings towards the ploughed land decrease the lead angle.

6. **Adjustments for deeper ploughing**: The depth of the plough can be obtained by position and draft control levers of the hydraulic system. However, more depth can be obtained by:

    a. Adding extra weight to the plough

    b. Reducing the tilt angle. This brings the disc to a more nearly vertical position, but if the soil is sticky the tilt angle needs to be increased.

    c. If the ground is covered with thrash, set the disc in almost vertical position and add weight to the plough. In such soils notched disc gives better results.

Overhaul and maintenance:

1. Keep the bearing lubricated as described in your owner's manual.
2. Keep the disc bearing clean and properly adjusted frequently.
3. Check plough adjustments if the steering is hard.
4. Check the scraper adjustment frequently.
5. Coat disc blades for rust prevention with old crankcase oil.
6. Sharpen discs if the blades are dull. Sharpening may not be necessary if the angle of cut is correct.
7. Broken discs may be repaired with special welding electrodes.
8. Constantly check for loose nuts and bolts.

Skill Set (FMPE) 4: Operation, adjustment, and maintenance of disc harrows

Skills to impart: To understand the working of disc harrow

Tools and materials: Disc harrow

Disc harrow is a secondary tillage implement and it is used for seedbed preparation after primary tillage operation. It breaks the soil clods, pulverizes the soil, cuts the weeds, and smoothens the surface to give a fine soil texture suitable for plant growth. In light soils, it is also often used for primary tillage.

Types of disc harrow: Single action disc harrow

: Double action disc harrow

Harrow Adjustments

Disc harrow penetration:

The disc harrow penetration depends on many factors. The disc penetration can be improved by

(a) Increasing the disc gang angle, (b) Adding additional weight, (c) lowering the hitch point, (d) sharpening the disc edge, using a disc of smaller diameter, and lesser concavity, and (e) regulating the optimum travel speed.

Gang angle adjustment:

Gang angle is the angle at which the axis of the gang makes with a line perpendicular to the line of travel. It varies from 10 to 25 degrees in single and double action harrows. However, it may be up to 50 degrees in some offset harrows. Penetration increases by increasing gang angle but should be kept low to avoid plugging in wet soil. The gang angle can be changed by loosening the clamp bolts, shifting the gang frame on the main frame to the desired position and then tightening the clamp bolts.

Disc harrow leveling:

The fore and aft leveling of the implement is done by tractor top link adjustment i.e. lengthening or shortening of the top link length. If the tractor pulls to the right while in operation then the rear gang should be lowered little (top link lengthened). In case of tractor pulling towards the left side then the rear gang should be raised (top link shortened). The side-to-side leveling is done by turning the implement leveling lever clockwise or anticlockwise.

Offsetting the harrow:

The offset harrow can be operated directly behind the tractor or can be offset to the right or left side for working in orchards. The gangs can be offset with respect to the centerline up to 2 feet on either side.

Scraper adjustment:

The scraper should be 1/8” at the inner point and ¼” at the outer point. For spherical scraper the gap from the disc is kept ½”.

Skill Set (FMPE) 5: Calibration, operation, and repair of seed drills and planters

Skills to impart: To understand the construction and working of seed drills and the procedure of calibration

Tools and materials: Seed cum fertilizer drills, inclined plate planter, raised bed planter

SEED CUM FERTILIZER DRILL

Crops have different methods of sowing and planting. Some crops like wheat, gram, peas beans etc. have small size seeds and are sown at fixed row-to-row distances whereas plant-to-plant distance is not maintained. Seed cum fertilizer drill is a machine used for sowing small cereal and pulses seeds and simultaneous application of fertilizer. This machine performs the following functions:

a. It opens furrows to uniform depth

b. It drops measured required quantity of seed at a desired depth without causing much injury to the seed

c. It measures and drops the required quantity of fertilizer in the soil at the desired depth and location concerning the seed.

d. It covers the seed with soil and compact the soil around the seed

There are different designs of seed cum fertilizer drills which may be manual, animal drawn, and tractor-drawn type. In this practical exercise, we will study the typical tractor-drawn seed cum fertilizer drill, which is commonly used in India.

CALIBRATION OF SEED DRILL

The seed drills are usually provided with one indexing unit and the seed drill can be set at any particular seed rate. However, before operating the machine in the field, it is always essential to calibrate the seed drill for the desired seed rate off the field. The calibration of the drill avoids the chances of any faulty setting in the machine. The seed drill can be calibrated by the following procedure.

1. Jack up the drill to a sufficient height so that the ground wheel can rotate freely.
2. Measure the diameter of the ground wheel by a measuring tape or scale. Let us say D meter is the diameter of the ground wheel.
3. Calculate the working width of the seed drill. The working width (W) in meter is the product of a number of furrow openers (n) and the distance between two consecutive furrow openers (d) in meters. i.e W = n x d
4. Calculate the circumference of the ground wheel i.e. π x D in meter.
5. Calculate the number of revolutions (X) of the ground wheel that would be required to cover an area of $1/25^{th}$ of a hectare i.e. 400 m^2 as follows

$$X = \frac{400}{\pi DW}$$

6. Fill the seeds in the seed box up to the desired level. Then give X revolution to the ground wheel and collect the seed from all the seed tubes separately and measure the weight (Y kg). Care should be taken that the ground wheel is rotated in approximately the same speed that is obtained in the field at the usual operating speed of the seed drill.

7. The seed rate is calculated as 25 x Y kg/ha.
8. The same procedure is repeated for different positions of the hand lever of the indexing unit till the desired seed rate is obtained.
9. If a large variation of the mass of seed between different furrow openers is observed, then the metering units of the seed drill may be checked for any mechanical fault or clogging and corrected. Variation in seed quantity dropped in different seed tubes from the average should not be more than 7%.

Skill Set (FMPE) 6: Calibration, adjustments, operation and maintenance of sprayers and dusters

Skills to impart: To learn the construction working of various types of sprayers and duster

Tools and materials: Knapsack sprayer, rocker sprayer, power mist blower cum duster, pedal-operated sprayer

Sprayers and dusters are plant protection equipment used for the application of chemicals and pesticides to control pests and diseases in crops. Sprayers are used for application of liquid formulations and wettable powders, whereas dusters are used for application of dust formulations. There are different types of sprayers available such as stirrup pump sprayer. There are also different types of dusters available.

Calibration of Sprayers

Calibration of sprayer is done to ascertain the application rate of any sprayer. For calibrating the sprayer, spraying is done in a known area and the spray liquid consumed is measured. Then the rate of application is determined in liters per hectare. First fill water in the tank and mark the liquid level in the tank. Mark out an area of 2.5m x 4m (10 m^2) and start spraying in the marked out area. On completion, fill the tank with water up to the initial level using a measuring flask and note down the volume of water used. Then calculate the rate of application as below.

Rate of application (lit/ha) = volume of water used (lit.) x 1000

PRECAUTIONS

1. Proper dress and safety items like glasses, gloves, etc. should be used while spraying.
2. Always spray in the direction of wind.
3. Never suck the liquid with your mouth
4. Check for any leakage during usage
5. If any type of discomfort is felt during or after spraying, then consult a doctor
6. Ensure that no animal or human being is present near the spraying site.
7. After spraying is complete drain out the spray solution and wash the equipment properly with clean water.
8. Properly clean your hair, nails, hands, and feet with soap after spraying work is completed.

Skill Set (FMPE) 7: Operation and maintenance of power-operated weeders

Skills to impart: To learn the construction, working, and maintenance of power weeders

Tools and materials: Power weeder, rotary tillers

Power tillers are self-propelled machines attached with rotary tiller unit for tillage. The power tillers are usually having engines with 8hp or more power. However, power tillers with small engines are also available and usually marketed as power weeders. The power weeders are suitable for hilly regions due to their smaller size and light weight. The power tillers/weeders are provided with either petrol or diesel engines. The operation and maintenance of power tillers/weeders differ according to the type of engine provided.

Safety Precautions:

Exhaust Precautions:

- Never inhale exhaust gas. It contains carbon monoxide, a colorless, odorless, and extremely dangerous gas that can cause unconsciousness or death.
- Never operate the engine indoors or in a poorly ventilated area, such as a tunnel or cave etc.
- Exercise extreme care when operating the engine near people or animals. Keep the exhaust pipe free of external objects.

Refueling precautions:

- Be sure to stop the engine before refuelling.
- Do not overfill the fuel tank.
- If fuel is spilt, wipe it away carefully and wait until the fuel has dried before starting the engine.
- When changing oil, make sure that the fuel cap is secure to prevent spillage.

Fire Prevention:

- Do not operate the engine while smoking or near an open flame.
- Do not use the engine around dry brush, twigs, cloth rags, or other flammable materials.
- Keep the engine at least 3 feet (1 meter) away from buildings or other structures.
- Keep the engine away from flammables and other hazardous materials (trash, rags, lubricants, explosives).

Protective Cover:

- Place the protective covers over the rotating parts. If rotating parts, such as the driving shaft, pulley, belt, etc. are left exposed, they are potentially hazardous. To prevent injury equip them with protective covers or shrouds.
- Be careful of hot parts. The muffler and other engine parts become very hot while the engine is running or just after it has stopped. Operate the engine in a safe area and keep children away from the running engine.

Surroundings:

- Operate the engine on a table, level surface free of small rocks, loose gravel, etc.
- Operate the engine on a level surface. If the engine is tilled, fuel spillage may result.

NOTE: operating the engine at a steep incline may cause seizure due to improper lubrication even with a maximum oil level

- Be careful of fuel spillage when transporting the engine. Tighten the fuel tank cap securely and close the fuel strainer cock before transit.
- Do not move the engine while it is in operation.
- If the engine will be transported over a long distance or on rough roads, drain fuel off from fuel tank to prevent fuel leakage.

Pre-Operation checks:

- Carefully check fuel pipes and joints for looseness and fuel leakage.
- Leaked fuel creates a potentially dangerous situation.
- Check bolts and nuts for looseness
- A loose bolt or nut may cause serious engine trouble.
- Check the engine oil and refill if necessary.
- Check the fuel level and refill if necessary, TAKE CARE not to overfill the tank.
- Wear snug-fitting working clothes when operating the engine.
- Loose aprons, towels, belts, etc. may be caught in the engine or driving train causing a dangerous situation.

Maintenance of Power tiller/weeder

Petrol engine power tillers

The usual maintenance schedule for petrol engines is given below. The operator should follow the maintenance schedule provided by the manufacturer.

Engine oil level check

- Check the engine oil level with the engine stopped.
- Place the tiller on a firm level surface with the rotor set on the ground so that the engine becomes level.
- Remove the oil filler cap/dipstick in the oil filler neck, but do not screw it in.
- Remove the oil filler cap/dipstick and check the oil level.
- If the oil level is near below the lower level on the dipstick, fill with the recommended engine oil to the upper level (top of the oil filler neck)
- Oil affects performance and service life. Use 4-stroke automotive detergent oil.
- SAE 10W-30 is recommended for general use. Check that the O-ring (4) is in good condition, replace it if necessary.
- Apply engine oil to the O-ring.
- Reinstall the oil filler cap/dipstick securely.

Engine oil change:

- Drain the used engine oil while the engine is warm. Warm oil drains quickly and completely.
- Place a suitable container under the engine oil drain bolt.
- Remove the oil filler cap/dipstick drain bolt sealing washer and drain the engine oil into the suitable container.
- Place and dispose of used engine oil in a manner that is compatible with the environment. Install the drain bolt and new sealing washer. Tighten the drain bolt to the specific torque (18 n.M/1.8 KGF/13 IBF.ft).
- With the tiller on a level surface, fill the recommended engine oil to the upper level. Install the oil filler cap/dipstick.
- Recheck the engine oil level
- Make sure there are no engine oil leaks.

Caution while changing engine oil:

- Used engine oil contains substances that have been identified as carcinogenic.
- If repeatedly left in contact with the skin for prolonged periods, it may cause skin cancer.
- Wash your hands thoroughly with soap and water as soon as possible after contact with used engine oil.

Air Cleaner Check/Cleaning/Replacement:

A dirty air cleaner element will restrict airflow to the carburetor, reducing engine performance. If the engine is operated in dusty areas, clean the air cleaner element more often than specified in the "MAINTENANCE SCHEDULE". Operating the engine without an air cleaner element or with a damaged air cleaner element will allow dirt to enter the engine, causing rapid engine wear.

- Remove the throttle cable from the hose band clamp
- Loosen the hose band screw and disconnect the air cleaner hose and then remove the air cleaner cover
- Remove the foam element and paper element
- Carefully check both elements for holes or tears and replace them if damaged.
- Check the air cleaner elbow packing and cover packing for deterioration or damage.
- Wipe dirt from the inside of the air cleaner cover, air cleaner hose and air cleaner elbow with a moist rag. Be careful to prevent dirt from entering the air cleaner elbow that leading to the carburettor.
- Clean the foam element in warm soapy water, rinse and allow to dry thoroughly, or clean with a high flush point solvent and allow to dry thoroughly.
- Dip the foam element in clean engine oil and squeeze out all the excess oil.
- Excess oil will restrict air flow through the form element and may cause the engine to smoke at startup.

- Tap the paper element several times on a hard surface to remove dirt, or blow compressed air (not exceeding 207 kPa, 2.1 kgf/cm^2, 30 psi) through the paper element from the inside. Never try to brush off dirt, brushing will force dirt into the paper fibres.
- Assemble the air cleaner n the reverse order of disassembly.

Clutch cable check/ adjustment

Check

- Check for any deterioration or damage to the clutch cable
- Squeeze the clutch lever several times. If there is a problem, adjust the clutch cable. If there is a problem yet, disassemble the clutch lever and clean the parts.

Adjustments

- Remove the belt cover set V-belt so that the V-belt joint area is not located between the drive pulley and driven pulley.
- Squeeze the clutch lever ten times.
- Turn the clutch stopper pin counterclockwise with the torque wrench and read the maximum torque until the clutch lever is fully seated
- Squeeze the clutch lever ten times and recheck the lever torque. After adjustment, tighten the lock nut.

Transmission oil level check

- Check the transmission oil level with the engine stopped.
- Place the tiller on a firm level surface with the rotor set on the ground so that the engine becomes level.
- Remove the oil filler cap and check the oil level is up to the lower edge of the oil filler hole.
- If the level is low, fill with the recommended transmission oil to the upper level (up to the lower edge of the oil filler hole)
- Recommended transmission oil: SAE 10W-30 API service classification SE or higher
- Check that the O-ring is in good condition, replace it if necessary.
- Apply transmission oil to the O-ring.
- Reinstall and tighten he oil filter cap securely.

Sediment cup cleaning:

- Gasoline is highly flammable and explosive you can be burned or seriously injured when handling fuel.
- Keep heat, sparks, and flame away. Handle fuel only outdoors. Wipe up spills immediately.
- Turn the fuel valve lever to the drain position while pushing the stopper button then drain the fuel into a suitable container.
- Turn the fuel valve lever to the “OFF” position
- Remove the sediment cup and O-ring

- Be careful not to spill the fuel from the sediment cup.
- Wash the sediment cup in a non-flammable solvent and dry it thoroughly.
- Place a new O-ring in the float chamber and install the sediment cup.
- Tighten the sediment cup to the specified torque.

Engine idle speed check/adjustment:

- Use a tachometer with graduations of 50 min^{-1} (rpm) or smaller that will accurately indicate a 50 min^{-1} (rpm) change.
- Warm up the engine.
- Stop the engine and connect a tachometer according to the manufacturer's operating instruction.
- Start the engine and check the idle speed.
- If the idle speed is out of the specification, turn the throttle stop screw to obtain the specified standard idle speed.

Spark plug inspection/adjustment/replacement:

- If the engine has been running the engine will be very hot. Allow it to cool before proceeding.
- Clean any dirt from around the spark plug. Remove the spark plug cap
- Remove the spark plug with a spark plug wrench.
- Visually inspect the spark plug. Replace the plug if the insulator is cracked or chipped.
- Remove carbon or other deposits with a wire brush.
- Check the sealing washer center electrode and side electrode for damage.
- Measure the plug gap with the thickness gauge. If the measurement is out of the specification, adjust by bending the side electrode. Recommended sparks plug gap: 0.70-0.80MM
- Install the spark plug finger tight to seat the washer, then tighten it to the specified torque.

Throttles cable check/adjustment:

- Check for any deterioration or damage to the throttle cable.
- Check the throttle lever for smooth operation.
- Measure the throttle lever free play at the lever tip. Recommended free play: 5-10 mm
- If the throttle lever free play is incorrect, loosen the lock nut and turn the adjusting nut in or out as required.
- After adjustment, tighten the lock nut securely.

Fuel tank and filter cleaning:

- Gasoline is highly flammable and explosive. You can be burned or seriously injured when handling fuel.
- Keep heat, sparks and flame away. Handle fuel only outdoors. Wipe up spills immediately.
- Remove the fuel tank. Remove the two tube clips and disconnect the fuel tube.

- Remove the fuel filter joint. Remove the O-ring joint in non-flammable or high flash point solvent.
- Inspect the fuel filter screen to be sure it is undamaged. Clean the fuel tank with non-flammable or high flash point solvent and allow to dry thoroughly.
- Check to be sure the new O-ring is in place and install the fuel filter joint.
- Tighten the fuel filter joint to the specified torque.
- Install the fuel tank. Make sure there are no fuel leaks.

Operation and Maintenance of Air-Cooled Diesel Engine Power Tillers

General Guidelines for Operation

- Attention for safe operation
- The fuel must be filtered by silk fabric or settled for 24 hours before used. Do not add oil into fuel tank or crank shaft case when the engine is running
- Burnable and explosive goods should not exist around the engine and the place for installation should be plain and ventilated.
- Do not touch muffler with your hand when the engine is running or just after it has stopped.
- The diesel engine must be run under rated power and rated speed. If you detect abnormal phenomenon, stop the engine immediately to check and remedy.
- New engine or newly maintained one must be run at low speed and low load at first 20 hours. Do not allow to run it at high speed and full load.
- Only use light diesel fuel for diesel engine. (No.0 in summer No. 10 or No. 20 in winter) Do not allow dust or water in the fuel and fuel tank.
- Do not wash the core of air filter, because this part is dry type. When power of engine is not good or the color of exhaust is abnormal, change the core. Do not operate the engine without the core of filter.
- In winter, if it is difficult to start the engine, pull out the plug and fill 2cc lube oil into the hole and then return the plug. Keep plug in tight condition. The engine can absorb dust and be damaged if the plug is taken away.
- Check fuel pipeline before refilling fuel oil and starting the engine. If there is air in the pipeline, drain it out. The detailed method is to loosen the nut of connection between injection pump and fuel pipe and drain out the air until there is no bubble in fuel.
- Lubricant inlet: Set the engine on plane ground and then fill lubricant into the inlet. When checking oil level, put the oil scale into the inlet lightly. Do not turn the oil scale.
- Push decompression lever down to start the machine. If your engine is still a newer one, its life would be shortened for over-load. At first 20 hours the engine must be started and stopped according to test run method.
- Avoid over-load. Avoid over load during test run.
- Change machine oil regularly. Change machine oil once every twenty hours or at the end of first mouth at primary running time and then once every three months or 100 hours.

- Starting of the Diesel Engine: Recoil Start: When the engine is running, do not pull the recoil handle otherwise the engine may be damaged.

Running of the Engine:

- Preheat the machine for three minutes at no load. Set the speed governor lever of the engine at the required speed position.
- Check whether there is abnormal sound and vibration?
- Check whether combustion is not good or over speed?
- Check whether the colour of exhaust gas is normal (black or too white).
- if any of the above phenomena are detected, stop the engine immediately and contact our local dealer.

Stopping the engine

- At first set the speed governor lever at a low speed position before stopping the engine and then run the engine at no-load for three minutes.
- Set the speed governor lever at the stop position.
- Decrease the load gradually when stopping the engine. Sudden stop of engine will cause abnormal increase of temperature. Do not stop engine with decompression lever.
- Set the fuel cock at OSO (stop position)
- If the engine possesses motor type starter, turn the start key switch to OFF position. Pull out the recoil handle slowly until pressure is felt by your hand (that means at the point of compression stroke, where the intake and exhaust valves are closed), and then let the handle back to its natural position so that it can prevent dust when the engine is not used.

Maintenance of Diesel Engine:

Daily check and maintenance

- Check the oil level of the machine to see whether it is between the upper and low limit.
- Check whether there is an oil leakage phenomenon.
- Clean up the dirt and greasy dust on the diesel engine its appendage and keep the engine clean.
- Remove malfunction detected during operation.

Storage for a long period:

Follow the following procedure if the power tiller is to be stored for a long period.

1. Run the machine for three minutes and then stop the machine.
2. Drain away the lubricant before the engine becomes cool and then refill new.
3. Disassemble the rubber plug on the cover of the rocker shaft then fill about 2cc lubricant into it and return the plug to its position.
4. Recoil type Start: push down and keep the decompression lever at the non-compression point and then pull the recoil starter two or three times.

5. Motor-driven type start: keep the decompression lever at the non-compression point and let the engine rotate for two or three seconds with the start key switch on “start” position (do not run the engine)
6. Pull up the decompression lever and pull-out recoil starter slowly until the resistance is felt by your hand (that is at the point of the compression stroke, where the intake and exhaust valves are closed, which can precent engine from rust).
7. Clean out machine oil and dirt from the engine and put the engine at a dry place.

Skill Set (FMPE) 8 : Operation, adjustment and maintenance of threshing and harvesting machinery

Skills to impart : To learn the operation and maintenance of reaper and thresher

Tools and materials : Reaper, paddy harvester

VERTICAL CONVEYOR REAPER

The self-propelled vertical conveyor reaper (VCR) is used to harvest cereal crops like wheat and paddy. It consists of the following units:

1. **Engine**: it consists of a single cylinder, air cooled diesel engine of 4 HP with rated rpm of 2600 rpm.
2. **Power transmission system:** the power from the engine is transmitted to the main drive shaft by belt and pulley drive. Power from the drive shaft is then transmitted to the harvester unit gear box by chain and sprocket drive. Power from the drive shaft is also transmitted to the transmission gear box of the reaper by chain and sprocket drive. The speed is reduced in the reaper gear box (bevel gear) and transmitted to the crank shaft of the reaper. At the other end of the crank shaft, there is a crank pin to which the pitman of the cutter bar is attached. The rotary motion of the crank shaft is converted in to reciprocating motion of the knife through the crank pin and pit man shaft. Power from the transmission gear box is given to the traction wheels.
3. **Harvester unit:** this is the unit which harvest the crop. It consists of a reciprocating cutter bar with knives and counter shear (ledger plates), crop dividers, star wheels, lugged conveyor belts, pressure springs, vertical conveyor chain with lugs, harvester board. The left divider divides the uncut crop from the crop to be cut. The other row dividers guide the crop to the star wheels. Then the crops are lifted by the lugged conveyor belts and fed to the cutter bar. After the crop is by the cutter bar, the crop is passed on to the harvesting board and kept vertical by the pressure springs. Then the cut crop is conveyed vertically by the vertical conveyor chain to the right side and delivered in a windrow.
4. **Transmission gearbox and traction wheel:** the speed is further reduced by the transmission gear box and torque is increased at the traction wheel. The machine is provided with two pneumatic lugged wheels of travel.
5. **Controls and handle:** the machine is provided with two handles for the operator. The controls include the transmission gear shift leaver, one master clutch, one harvester unit clutch, one right wheel clutch and one left wheel clutch. The machine has two forward speeds (DI and DII), one neutral (N) and one reverse (R) positions. The master clutch engages and disengages power to the transmission gear box and harvester unit gear box. The harvester unit clutch engages or disengages the power to the cutter bar. The left and right clutch engages or disengages power to the left and

right wheels respectively. While making a turn, one wheel has to be disengaged by depressing the clutch leaver.

Operational Safety

1. The operator must read the instruction manual of the machine carefully before operating the machine.
2. Before starting check the fuel and oil levels. Inspection of the machine for any loose parts and links must be done before operating.
3. Do not undertake checking, repair, or adjustment when the machine is running.
4. No one should be allowed to stand in front of the machine while working.
5. Stop the machine in case of any obstruction, malfunction, or noise.
6. While turning or driving in reverse, reduce the accelerator and stop the cutting unit.

Operating procedure in field

1. The height of cut is determined by the operator. The operator should have enough practice to maintain uniform cutting height.
2. Cut the crop at the four corners in about 3 x 3m area for easy turning of the machine at corners.
3. Pay attention to obstructions like brick stones, metal wires, pit holes, etc in the field while operating.
4. Enter the field from the left corner and harvest clockwise.
5. If the crop is lodged (fallen) heavily, harvesting should be done in the reverse direction of crop.
6. If the field is very wet the wheels skid heavily then postpones harvesting till the field condition is improved.
7. In a windy day, harvesting should be done in cross wind direction.
8. When the machine moves downhill, it is advised to control manually.
9. If the crop or weeds clog in the cutter bar then stop the machine immediately. Clear the clogging and then resume work.
10. Do not add fuel to the engine while in running condition.

Maintenance

1. The cutting performance is greatly influenced by the knife is blunt or broken. It is advised to sharpen or replace the knife.
2. If the knife clearance becomes more than 1.5mm then adjust the knife clip. Check also the ledger plates for wear and tear.
3. When the riveting of the knives and ledger plates are loosened, then fasten them.
4. If the knife is bent, then shape or replace it.
5. If the grain lifter star wheel is worn or broken, which influences the grain lifting, it should be replaced.

Storage:

Before storing the machine at the end of a season's work.

1. Clean the machine thoroughly before storing.
2. Lubricate all the parts properly before storing them.

MULTICROP THRESHER

This equipment is developed by CIAE, Bhopal and it incorporates the desirable features of a wheat thresher and IRRI axial flow paddy thresher. It consists of the following components

1. Feeding chute
2. Spike tooth cylinder
3. Concave
4. Cylinder top cover (semi-circular/semi-hexagonal)
5. Straw thrower
6. Aspirator blower
7. Cleaning sieve

Working of the thresher:

The thresher can be used for both wheat and paddy crops with adjustment in the top cover. The semi-circular top cover is used for wheat and other crops where the straw can be broken into small pieces. The crop material moves axially, and the straw is discharged at the other end by the straw thrower. A semicircular plate is inserted between the cylinder and straw thrower while using the semicircular top cover for wheat and other crop. The spike length of the cylinder can be adjusted from 50-70 mm. Three sizes of concave made up of 6 mm square bars with 7 mm, 9 mm and 25 mm gap between two bars are provided. The concave clearance can be adjusted from 7-25 mm for different crops i.e.. cereals, pulses, oilseeds etc. three sizes of sieves 4.9 mm, 7.8 mm and 11.2 mm are available for different crops. An aspirator blower is mounted behind the cylinder with two sopenings, opening one at the separating chamber and another at the main grain outlet. The cylinder and shaker assembly get power through the blower shaft V-best and pulley drive.

Adjustments:

1. The cylinder speed can be varied for different crops by changing the pulleys in the power transmission.
2. The concave clearance can be adjusted for different crops by adjusting the length of spikes. The spikes are bolted to the threshing drum and can easily be adjusted.
3. The concave grate spacing can be changed by replacing the concave with another suitable concave as per requirement.
4. The blower speed can also be varied by changing the pulleys in power transmission.
5. The sieves in the sieve shaker can be easily replaced as per the crop requirement.

The top cover can be chosen between semicircular one for wheat, pulses, oilseeds etc. and semi hexagonal one for paddy crop and any other crop where fine straw pieces are not required.

Skill Set (FMPE) 9: Tractor driving

Skills to impart: To learn to drive 4-wheel tractor

Tools and materials: 4-wheel tractor

Tractors produce unit having different horsepower capacities. Various machines and farm implements can be attached and operated by a tractor in stationary and tractive conditions.

A. Starting a tractor

Check the tractor before starting

The following steps are required to be followed before starting a tractor for operation

i. **Look for safety:** Any loose nuts and bolts of the tractor and attached implements may lead to accident and safety hazard. Walk around the tractor and inspect before climbing. Visible loose nuts, bolts must be tightened.

ii. **Check tyre pressure:** Non uniform tyre pressure will lead to instability and create safety hazard while driving. Check condition of tyres for cuts and crakes. Check the tyre pressures and refill if required.

iii. **Check the fuel tank:** Sufficient fuel in fuel tank is required for operation. Check and make sure sufficient fuel is there in the fuel tank.

iv. **Check the system of engine:** Different engine systems need to perform properly for smooth operation of the tractor. Improper cooling and lubrication may lead to overheating and damage of engine. Check coolant level, and refill if required. Check the lubricating oil, oil filtre, radiator, battery terminals, and electrolyte levels to make sure they are in the desired range.

v. **Check the attached machinery and implements:** If any machinery or implements are attached to the tractor, they are required to be mounted securely. Check for proper securing of the machines and implements if attached behind the tractor.

vi. **Check operator's space:** Make sure the operator's space is clear from spilled fuel, oil, grease, crop residues, and other unwanted objects.

vii. **Climb up to the tractor' seat:** Climb up from the left sof the the tractor. Familiarize yourself with various tractor controls. Set the seat to easily reach the steering wheel, throttle and other controls with feet and hands. Wear and buckle the seatbelt.

B. Start the engine

The following steps are required to be followed when starting a tractor

i. **Keep the engine neutral:** If the engine is started while the power transmission is in engaged position, the tractor may suddenly move forward or backward which is highly dangerous. Press the clutch pedal with the left foot and engage the gear in neutral.

ii. **Engage the brake:** Press the brake pedal with right foot so that the tractor is do not move.

iii. **Engage the hand accelerator:** Move the hand accelerator to around half of its position.

iv. **Start the engine:** Place the key in the keyhole and turn the key clockwise to start the engine. Keep the engine throttle slightly to let the engine warm up for some time. If the engine does not start within 10-20 second, repeat the key operation after about 30 seconds.

v. **Keep the engine running:** Warm up the engine by keeping the engine run for about 2-3 minutes.

C. Operation of a tractor

i. **Follow operator's manual:** Tractor manufacturers provide operator's manual for each type of tractors. Operate the tractor according to operator's manual provided by the tractor manufacturer.

ii. **Lift the attached implements:** Engage the hydraulic lever with right hand and lift all the attached machines and implements.

iii. **Release parking brake:** Release the parking brake.

iv. **Disengage the clutch:** Press the clutch pedal to full with left foot to disengage power transmission.

v. **Engage gear:** Engage the tractor with desired gear depending upon the speed and load requirement. Lower gears are for slower speeds and higher torque while larger gears are for higher speeds and lower torque.

vi. **Start driving:** Release the clutch slowly and take the right foot off from the brake. Sudden release of clutch pedal will suddenly engage power to the wheels and tractor will suddenly move at higher speeds. Always watch ahead of the tractor.

vii. **Control throttle:** Change the throttle position if required depend on desired speed and load. Throttle can be fixed manually at desired level or can be changed with pedal accelerator. Tractor are made for durability and strength; they are not for driving fast. Tractors are extremely dangerous to control especially when turning curves and working on sloppy or undulated surfaces with attached machines and implements. Tractors also lack suspension and therefore bounced around on rough ground. Therefore, it should be operated at slow speed with precaution.

viii. **Change the gear:** If change of gear is required, reduce the engine speed by lowering the fuel throttle or accelerator. Bring the tractor in stationary condition. Press the clutch pedal and change to desired gear.

ix. **Reversing a tractor:** Change the gear to reverse position as in step (viii). Follow step (vi) and drive the tractor at low speed. Look at the rear while reversing a tractor.

x. **Be attentive:** Listen to any unknown noise or sound in the engine, power transmission etc. while driving and investigate for the causes and rectify them.

xi. **Avoid overloading:** Avoid overloading of tractor during operation.

D. Stopping a tractor

The following steps are required to be followed while stopping a tractor after operation.

i. **Lower the speed of engine:** Release the accelerator and lower the speed of the engine.

ii. **Stop the tractor:** Press the clutch and press the brake with both legs.

iii. **Set the throttle:** Change the throttle lever to lower position.

iv. **Change the gear:** Set the gear to neutral potion.

v. **Ground the attached implements:** Using the hydraulic lever, free and put all the attached machines and implements to the ground.

vi. **Turn the key off:** Turn off the start key and stop the tractor engine.

vii. **Remove the key:** Remove the key from the keyhole.

E. Parking a tractor

i. **Engage the parking brake:** Engage the parking brake and park the tractor.

ii. **Engage to low gear:** If the tractor is to be parked on a steep slope, engage the transmission to a low gear and park along with parking brake. It will help in preventing the tractor rolling down in case parking brake fails.

Tips:

i. Do not go too fast on the tractor and from the tractor.

ii. Use caution on slopes and hills. Use lower gear while driving up and down hill. Never press clutch pedal while driving downhill.

iii. First slow down while turning.

iv. Use caution when putting and taking off tractor attachments.

v. Avoid spilling of fuel over the engine.

vi. Do not remove radiator cap while the engine is hot.

vii. Never leave the key in the keyhole.

viii. Drive at low speed while overcoming obstacles.

ix. Stop the tractor on left side of the road.

x. Keep brake pedals interlock while driving on road.

Warning:

i. Never leave a tractor running and unattended.

ii. Do not permit any unauthorized person to ride the tractor.

iii. Never start a tractor unless seated on driver's seat.

iv. Do not start the tractor in a closed place or shed.

v. Do not sit or stand on implements while tractor is in motion.

vi. Do not get off from the tractor while in motion.

Skill Set (FMPE) 10 : Hitching of mould board (MB) plough to a tractor

Skills to impart : Learning how to hitch mould board plough to a tractor

Tools and materials : Tractor drawn MB plough, hitch pin

Follow the following steps to properly attach a MB plough to a tractor 3-point hitch linkages. Proper hitching of the plough improves stability and operation of the tractor and implement while in operation.

1. Bring the tractor in reverse, close to the MB plough and line up to the implement's lower hitch points.

2. Position the tractor to align the lower hole in the drawbar arm with the pin of the implement.
3. Lower the hydraulic arms using the tractor's hydraulic control lever until the positions of holes of the arms and pins of the implement are match.
4. Reposition the tractor such that the hole in the drawbar and at least one pin of the MB plough is closely matched.
5. Raise or lower the drawbar arms to match the implement hitch points.
6. Stop the engine, securely park the tractor and set the brakes.
7. Raise the implement using a jack stand or lever and push the connecting pin on the hole of the drawbar.
8. Move the MB plough or start the tractor and match the hole of the other drawbar and pin of the plough.
9. Restart the tractor to use the hydraulic system to raise and lift the arms if needed.
10. Attach both drawbar arms to the plough hitch points using proper size hitch pin and security clip.
11. Match the upper link of the 3-point hitch to the plough's upper hitch point. Secure the upper link with the plough using proper size pin and security clip. The upper link is adjustable by screw threads. Make proper leveling of the plough using the thread of the upper link.
12. Ensure connection is secure with locking devices such as clips or safety pins.

RENEWABLE ENERGY ENGINEERING (REE)

Skill Set (REE) 1: Rooftop solar systems

Skills to impart: A rooftop solar power system, or rooftop PV system, to generate electricity on the rooftop of a residential or commercial building or structure

Tools and materials: Solar PV Modules, Arrays and Systems, Inverters & Charge Controllers, Battery Storage, Switches, Connectors and Enclosures, Safety protection

Rooftop solar is a photovoltaic system that has its electricity-generating solar panels mounted on the rooftop of a residential or commercial building or structure. Rooftop-mounted systems are small compared to ground-mounted photovoltaic power stations with capacities in the megawatt range. Rooftop PV systems on residential buildings typically feature a capacity of about 5 to 20 kilowatts (kW), while those mounted on commercial buildings often reach 100 kilowatts or more.

A solar rooftop photovoltaic (PV) system mounted on the roof/space frame/shed of a building / parking structure is a power plant that converts solar energy to electricity to meet the property's energy needs or to feed into the grid. While anyone can build a solar rooftop system, the size of the installation varies substantially depending on the amount of available space, electricity consumed by the property, and the owner's ability or willingness to invest the capital needed.

1. Grid-connected solar rooftop PV system

As the name implies, a grid-connected solar rooftop photovoltaic system is connected to the grid with or without any battery backup. The light from the sun is converted into DC electricity by the solar panels which is converted into AC electricity by a grid-tied inverter and subsequently synchronized with the main grid. Here it is consumed by local loads. Surplus power, if any, is injected into the main grid.

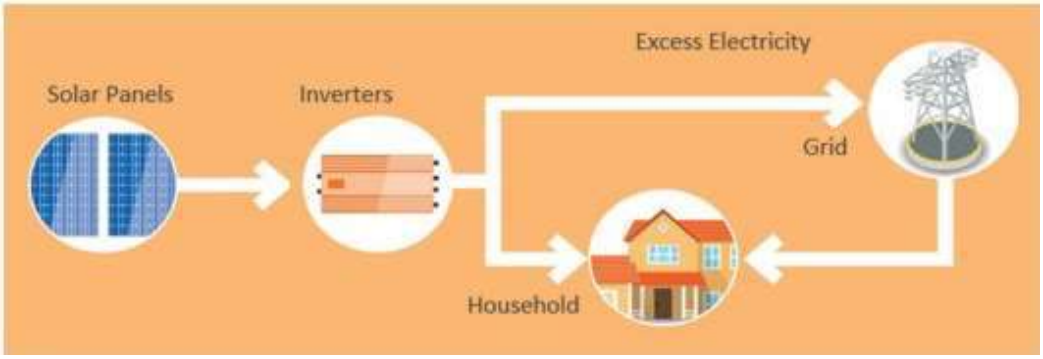


Fig. Grid-Connected Solar Rooftop System

2. Off Grid (Standalone) Solar PV Plants

The purpose of Off-grid (Standalone) Solar PV Plants is to provide electrical energy where conventional electrical energy is not available or is erratic (if available). These plants are generally not connected to the main grid. They are equipped with a storage battery. Due to the additional expense of the battery bank, are considered to be expensive. These plants are also installed at remote locations where backup power is required.

Fig. Off-Grid Solar Rooftop System

Components Of Solar Rooftop

The components of a Solar Rooftop system are as follows:

1. Solar Photovoltaic (SPV) Modules

There are a wide variety of modules available today which differ in the type of Semiconductor used, the manufacturing process, and the product quality. The vast majority of commercially available PV modules are made from semiconductors and differentiated into the three main varieties: mono-crystalline, polycrystalline and thin-film solar cells. The different types of PV module vary significantly by cost, efficiency, capacity, and appearance. The choice is highly dependent on the application; however, the most important thing is to ensure that they are compliant to the relevant national/international codes and standards, with respect to the need of the project.

Solar PV module manufacturers use the standard test conditions (STC) output parameters for display on their nameplates. At STC, PV modules are exposed to artificial sunlight with an intensity of 1000 W/ m2 at 25°C and air mass 1.5 (AM1.5) to measure the output. The performance of a solar PV module in site conditions differs from those of the STC. Selection of array configuration is based on location specific irradiance, in a software-based simulation or based on the local available metrological data.

2. Battery storage – type and classifications

In a standalone Solar Rooftop System, battery storage is required if electrical loads are required to operate at nighttime/non-Sunshine hours, or during extended periods of cloudy or overcast weather when the PV array by itself cannot supply enough/desired power. The primary function of a storage battery is to provide stored electricity during non-sunshine hours.

Some of the Secondary batteries that are commercially available and viable for use in photovoltaic systems include. Flooded Lead Acid Batteriesω Valve Regulated Lead Acid (VRLA) Batteriesω Lithium Ion (Li-ion)ω The different types of batteries commonly used in PV systems are described below

3. Charge Controller

The charge controllers are included in most PV systems to protect the batteries from overcharging and/or excessive discharge. The minimum function of the controller is to disconnect the array when battery is fully charged and disconnect the load when the battery is discharged up to a predefined level (Low voltage cut-off).

4. Inverters & other Electronic Equipment

The photovoltaic array and battery produce DC current and voltage. The purpose of an inverter is to convert the DC electricity into a form suitable for AC electrical appliances and/or exportable to the AC grid. The typical low voltage (LV) supply electrical load will be either 230V AC single phase or 415V AC three phases. The inverter in a stand-alone power system takes its power from the batteries to supply the AC circuit(s). The system controller (voltage regulator) itself can have an MPPT. The

advantage of the MPPT controller is to optimize the battery charging. This function has no impact on whether the inverter itself will supply power to any AC circuits. Stand-alone inverters are typically voltage-specific, i.e., they are manufactured to operate from a specific nominal battery voltage e.g., 12V, 24V, 48V, 96V, 120V DC or above, as per their power handling capacities. The inverter will convert the solar DC power to an AC sine wave that matches the AC supply in voltage and frequency to which it is connected. The rooftop systems could be grid-tied as well. There are some important changes in terms of connections and equipment such as inverters due to connection with the distribution power system. Such installations also need to comply the safety measures, Regulations, and Grid Protocols of the respective Country. The key role of the grid-connected inverters is to synchronize the phase, voltage, and frequency of the AC inverter output with that of the grid. Solar grid-tie inverters are designed to instantly disconnect from the grid if the utility grid goes down to ensure that in the event of a blackout, the grid-tie inverter will shut down to prevent the energy it produces from harming any line workers who are working on power grid. This feature is known as the islanding property of the inverter which is a mandatory safety norm as per international standards and has to be compiled by every grid-connemanufacturer manufacturers. Connecting Solar Rooftop system to the main grid may provide multiple benefits as below: Solar Rooftop Systems are typically designed with extra capacity to take care of energy demandω during the months when solar radiation is low. If the system is connected to the main grid, surplus power can be injected into the grid, which will increase the capacity utilization factor of the plant. • The electrical load connected to the system will have more flexibility in the use of electrical appliances when Solar Rooftop System is connected to the main grid. • Due to the availability of grid, battery capacity may be reduced or even removed if the grid is reliable. Such a type of technical provision can also be done, as and when the main grid is extended to the areas where Standalone Solar Rooftop Systems are installed. If the main grid is extended to such locations Solar Rooftop systems may become obsolete or have less importance due to their limited power generation capacity in comparison to the main grid. The best way to avoid such a situation is to make the Solar Rooftop Systems compatible to interface the main grid.

5. Balance of Systems Equipment

In addition to the PV modules, battery, inverter and charge controller there are other components required in a Solar Rooftop System; these components are referred to as Balance of Systems (BoS) equipment. BoS equipment included.

a. **Solar Array Mounting Structure:** The equipment used to safely secure the PV modules to the mounting surface or ground. These Structures are normally customized/designed with respect to the need of the location capacity of Solar PV Systems and the place of installation. It can be on the ground or rooftop.

b. **Cabling:** Both DC and AC cabling is required to connect components. The selection of size and type of cables will be based on the technical design of the Solar PV System and must conform to the relevant national / international standards.

c. **Array Junction Box (String Combiners):** This may or may not be required depending on the type of inverters e.g., Central / String Inverters. Whereas, PV strings can be directly connected to string inverters, for Central Inverters the strings must be combined in the combiner boxes. Combiner boxes are required to connect the module-strings in series or parallel depending upon the requirement of the design of the Solar Power Plant.

d. **Protection and Disconnect Switches:** These components ensure the isolation and safety of the Rooftop Solar Power Plant. The prevailing codes of practice must be followed while incorporating these devices in the design of the SRT systems.

e. **Earthing:** Earthing system is a protection system for Solar Rooftop Systems, through which all the electrical installations are connected to the earth to protect living beings from getting electric shocks

f. **Lightning Protection:** May be installed depending on the requirement to protect the system from lightning strikes as per international / local standards.

g. **Metering:** Measures the quantity of electricity generated by solar or quantity of electricity consumed by a customer.

Skill Set (REE) 2	**: Basics of a solar PV system and its components**
Skills to impart	: Basics of a solar PV system and its components
Tools and materials	: Solar PV Modules, Arrays and Systems, Inverters & Charge Controllers, Battery Storage, Switches, Connectors and Enclosures, Safety protection including electrical insulation, protection from lightning, load bearing capacity and earthing, Utility Interconnection, cables, Meters

The heart of a solar PV powering unit is solar cell. Depending upon its application the PV system may also contain an inverter (ON GRID system) and also a storage device (OFF GRID system).

Solar cell to solar PV array:

Solar cell: It's a device for converting sunlight into electrical energy. Normally a solar cell is made up of a p-n junction diode.

Parameters of solar cell/ <u>solar module</u>

i. Short circuit current (I_{sc}): the maximum current a solar cell/ module can produce, depends mainly on cell technology, cell area, available solar radiation. It is measured in Ampere.

ii. Open circuit voltage (V_{oc}): the maximum voltage a solar cell/ module can produce, depends mainly on operating temperature and cell technology

iii. Maximum power point (P_m): This is the amount of maximum power a solar cell/ module can supply at Standard test condition (STC: Radiation 1000w/m^2 AM 1.5 and Temperature 25^oC)

iv. Current at Maximum power point (I_m): Current produced by solar cell/module when operating at maximum power point

v. Voltage at Maximum power point (V_m): Voltage produced by solar cell/module when operating at maximum power point

Batteries: Batteries used in solar PV systems get charged by the solar panel and upon used on connecting with load get discharged. To meet this requirement, the batteries in the PV system should be rechargeable.

Parameters of Batteries

1. Battery terminal voltage in volts
2. Charge storage capacity in Ampere hour Ah
3. Depth of discharge in percentage

4. Operating temperature (for lead acid -15ºC to +60ºC)
5. Number of useful cycles
6. Life cycles in year
7. Self-discharges

Battery terminal voltage: This parameter determines the suitability of a battery for a particular load, higher the load requirement higher should be the battery terminal voltage. A fully charged battery connected with no load shows maximum terminal voltage which reduces with time during use i.e. the terminal voltage reduces as it gets discharged. The no load terminal voltage or open circuit voltage is the same as electromotive force of the battery i.e. $V_o=V_{emf}$. However, for operating a battery it is necessary to know the operating voltage which should be shown by a battery across its terminal on connecting with a load. The standard operating voltage available are 1.5 V, 3.0 V, 6 V, 12 V, 24 V, etc. Another important understanding of the battery is Cut-off voltage which specifies when to stop availing power supply from a battery.

Charge storage capacity in Ampere hour (Ah):

The capacity of battery marked for the temperature 25ºC (STC) which may vary with change in temperature. Hence

Energy stored (watt-hour) = Capacity (Ah) X Terminal voltage

Depth of discharge (DoD) in percentage:

For practical purposes besides knowing the charge content of the battery it is very important to know that to what extent the charge can be drainedbattery, battery and it is denoted by DoD. 50% DoD means that safely 50 % of the total charge content of a battery can be used.

Construction of solar cell:

The n side of the solar cell is relatively thinner than the p side but heavily doped and faces the sun. For catching the maximum sunlight, the n side is coated with optically transparent and antireflecting coating which is also conducting in nature and acts as electrical contact of the solar cell.

As the n-side of the solar cell is thin the light incident on it reaches the depletion region and breaks the covalent bonds there to produce photo -volt.

Generation of photo -volt:

On incidence of sunlight with appreciable amount of photonic energy electron-hole pairs are formed in the depletion region of the solar cell i.e. the p-n junction diode. The ionic charge barrier in the depletion region prevents these newly formed free electrons and holes to get recombining. Rather the free electrons move towards the +ve charge barrier and holes move towards the -ve charge barrier that exists in the depletion region. Consequently, the positive and negative charges are piled up on the p-side and the n-side respectively producing the photo-volt and hence capable of driving the external circuit.

Skill Set (REE) 3: Design of an On-grid and Off-grid PV System

Skills to impart: On-grid and Off-grid solar PV system

Tools and materials: Solar PV Modules, Arrays and Systems, Inverters & Charge Controllers, Battery Storage, Switches, Connectors and Enclosures, Safety protection including electrical insulation, protection from lightning, load bearing capacity and earthing, Utility Interconnection, cables, Meters

PV systems are mainly categories into two groups, namely battery-backed standalone systems and Grid-connected PV systems which are further divided in

1. Grid-connected PV systems for small power application
2. Grid-connected PV systems for large-scale power application

The main components of a gsystemnected system are (a) PV modules, (b) a solar power conditioning unit (SPCU), and a load or grid. Solar Power Conditioning unit (SPCU) is an integrated system that provides the facility to charge the battery bank through either a Solar or Grid/DG set. An SPCU (solar power conditioning unit) will consist of the following parts:

MPPT Charge control: In this type of, an electronic conversion unit changes the voltage of the solar panel to the battery level. Here since the panel voltage is independent of the battery voltage level, the panels are operated at its peak power point. Hence utilization of the panel is maximized.

Inverter: In simple terms this is the heart of the solar PCU. This part is responsible for converting the DC voltage from the battery to AC power to the output. Different technologies exist for inverters. In the transformer-based inverter, the dc-ac inversion happens at low voltage of the battery and then it is stepped up using a transformer. This technology is being replaced by High efficiency switched mode power supply (SMPS) based inverters around the world. The SMPS is used to transform the DC to high-voltage DC and it is then inverted.

Grid Charger: It is an auxiliary charger in a Solar PCU. It charges the battery from the grid when solar is not available. Different types of chargers are available on the market. Some inverters are even bi-directional and can charge the battery in the reverse direction from the grid.

Selector Mechanism: The system is always placed in the solar mode, under this condition the power from the PCU will be coming from the inverter. But when solar energy is not sufficient the appliances will be operated from the grid. This is made possible with the help of a relay

Battery bank: The battery bank stores the solar charge for use by the inverter. In a normal day solar energy keeps varying depending on cloud formation, shadow and time of day etc. The loads connected to the inverter will also be having its own variations in loading pattern. Hence it is essential to have a battery backup to act as a buffer and for storage of electricity produced through solar. Use C10 tubular batteries which are available in the market exclusively for solar systems.

Control Algorithm

This is the part which distinguishes a solar PCU from an ordinary inverter + solar charger. This is the part which controls the priority and optimally select which is the source of charging solar or grid or both. It also selects the source of ac output to be either from the inverter or from the grid. It can operate in either Solar-Battery-Grid or as Solar-Grid-Battery. In solar-battery-grid, the battery is charged first and also supports the inverter to power the appliances. Once the solar energy stops, the PCU starts consuming the stored energy from the battery. Once the stored energy is used to a particular level, the inverter stops and the connection to the appliances is given from the grid with the help of

output selector. The main focus here is to save the electricity bill cost. In the solar-grid-battery mode of operation, the battery is first charged with the help of solar and also supports the inverter to power the appliances. Once the solar energy stops coming, the appliances are run with the help of the grid using the output selector. The battery is not discharged in this case till there is a grid failure. This type is used at places where power outage is more, and the consumer wants to use the grid as long as it is available. The battery is kept as a backup to use when the grid fails. In this condition at daytime the load will work in solar power. Here the main purpose is to have uninterrupted solar power. The efficiency of the inverter is one of the most important factors which decides the overall cost of the system. For eg transformer-based inverter has only 70% efficiency, while for SMPS based high frequency inverter the efficiency is 90%. In short it is very important to choose the right type of technology for a solar PCU. Not doing so, one would never get the real benefit of the installed solar system

Design of Standalone PV system

Let us design a standalone solar PV system for a house using 5 fans of 60 watts used for 4 hours a day, 10, 20Watt LED tube each running 6 hours a day and a refrigerator of 500 watts for 5 hours. Consider battery autonomy for two days.

Step 1: maximum load calculation and total energy consumption

Step 2: Invertor capacity (considering efficiency 90%) =Total watts/efficiency= 1000/ (90/100) =1111VA

Total energy input to the inverter should be = 5400/90% = 6000Wh

Step 3: Solar charge controller unit capacity = wattage/system voltage = 1000/24 = 42A

So the specs of the charge controller here 24V, 42 A

Step 4: Battery selection

Daily energy need X (2+1) (for 2day autonomy)	System voltage	Battery capacity	DOD	Actual battery capacity
6000*3= 18000	24	750	50%	750/50% = 1500Ah

Step 5: Module sizing

To get Daily energy need inverter input	Battery efficiency	Energy from module	Number of sunshine hours	Module wattage
6000Wh	95%(Say)	6316	5(say)	1263Watt

Step 6: Wiring and fuse

Maximum DC current across the module to inverter is

= Module wattage/ system voltage

= 1263/24

= 53A.

That is the fuse /circuit breaker should work at the current 53A

Maximum AC current across the inverter to load is

= Module wattage/system voltage

= 1000/230

= 5A. That is the fuse /circuit breaker should work at the current 5A.

Skill Set (REE) 4: Understanding the installation of roof top solar PV systems

Skills to impart: Installation of roof top solar PV systems

Tools and materials: Ball Pin Hammer, Plumb bob, Line dori, Screwdriver, measuring tape, Clamps, Nail puller, Drill machine, digging bar, Measuring square, Utility kni, Spade, Hand saw (Frame with Chisel PVC mallet blade), Spanner, Pliers (nose, side) Filers (flat, round)

Rooftop Solar PV System Installation Procedure

Before starting the installation process, the installer must go through all installation documents and verify the quantity and availability of listed equipment, accessories, and tools for installation and commissioning of the solar PV system. Verification of the quantity and availability must be done before starting the installation procedure to minimize the risk of project delay or an incomplete job due to non-availability or shortage of the equipment, accessories and tools. The installation and commissioning procedures for grid connected solar PV systems are presented in twelve steps. These steps are to be followed in sequence.

Step 1: Site survey and shadow analysis

Step 2: Installation of PV array mounting structure

Step 3: Installation and testing of structure earthing system

Step 4: Installation of PV modules

Step 5: Earthing of PV Module Frames

Step 6: DC cabling

Step 7: AC cabling and installation of inverter

Step 8: System protection and safety

Step 9: Placing of signage

Step 10: Pre-commissioning tests

Step 11: Commissioning the system

Step 12: Anti-Islanding functionality test

Step 1: Site survey and shadow analysis

The site parameters that influence performance and reliability of a PV system are - access to solar radiation, near shadow and far shadow, ambient temperature, air flow and ventilation, wind speed, height of building, terrain, orientation, dust level and pollution, salinity, humidity, extreme weather conditions etc. A number of parameters are likely to be variable from one site to another even in the same geographical area. Therefore, it is crucial to plan a solar PV project to suit the site parameters and also to select the right components and customize the design accordingly to ensure better performance and safety. An inaccurate site assessment will lead to wrong design and installation of a PV system, which eventually leads to poor maintenance, poor performance and unreliable system functioning.

Must have tools for site survey:

- Personal protective equipment (as applicable to site condition)
- A Solar Pathfinder or Sun eye to identify / determine shadow free area
- A compass to record direction (Mobile app is available)
- A measuring tape/ digital distance meter to measure distance
- An angle measuring equipment (Mobile app is available)
- A notebook
- A working partner (Never survey a site alone

Tasks to be performed during site survey:

- Determine PV array location conducting shadow analysis:
  - Carry out shadow analysis to find the area which is free from shadow in all days of the year
  - Ensure that the PV array will have safe access for maintenance and fire safety
  - Ensure that PV array has ample space for air cooling
  - Ensure that modules are protected from theft and vandalism

Conduct shadow analysis at site:

Objects that come in the path of the incident solar rays any time during the day, will cast shadows and hence reduce the solar generation. A taller object located in the east direction would cast shadows during morning and a taller object located on the west direction would cast shadows during the afternoon. When multiple rows are placed, one row can cast shadow on the other if not properly placed.

Procedures to follow for shadow analysis:

Shadow analysis – using solar pathfinder: The most accurate and easy method to determine usable and shadow free area is by using a solar pathfinder. The Solar Pathfinder is a simple but highly accurate tool for determining shadow free area at any location. The equipment works on a reflective principle rather than showing shadows. It can be used anytime of the day, anytime of the year, in either cloudy or clear weather. The actual position of the sun at the time of the solar site analysis is irrelevant. The sun path diagram provided with this device is latitude specific, which provides the percentage of solar radiation available at different times of the day. By positioning the solar pathfinder at the location where an object can cast shadows, one can easily determine whether the location is shadow free or if shadow is unavoidable, how much energy will be blocked by the shadow until what time and which months of the year. The picture below shows solar pathfinder (left) and sun path diagram (right). The images seen in the solar pathfinder are objects (trees) which will create shadows at different times of the day in different months of the year.

Shadow analysis – analyzing sun position:

When the position and height of the object are known, it is easy to calculate shadow length at different times of the day using a simple trigonometry formula as shown below. Azimuth angle and altitude angle can be derived from various web tools that are available in web domain. One such web tool is www.suncalc.org.

Step 2: Installation of PV array mounting structure

Failure of PV array mounting structures due to strong winds is a rising concern in Indian solar projects today. It is very common for PV array mounting structures to be conceptualized and designed primarily to enhance energy generation considering area specific tilt angle and use of tracking facility etc. A large number of solar PV systems are reported to be damaged due to inadequate design consideration for wind loading. Apart from the strength and wind loading capacity, a mounting structure must ensure that the PV array receives optimum solar radiation and reduces temperatures loss by allowing enough air circulation. It is also important to ensure that factors such as structure design, placement, orientation, tilt and shading are aligned with electrical string design and choice of inverter.

Tilt angle and orientation:

The recommended tilt angle of a module mounting structure to minimize wind pressure is $<15^{o}$ for a flat surface. However, a minimum tilt of 10^{o} should be maintained for natural cleaning of modules. Ideal orientation of a fixed PV Array should face towards true south (in northern hemisphere). However, for structural uniformity and to accommodate more capacity on a limited space of a RCC flat roof, the orientation could be aligned with roof orientation. A deviation up to 30^{o} with respect to true south will not have major impact on energy generation. In case of an inclined roof, PV modules should always be installed at the same tilt and orientation of the roof. A racked mounting structure over a inclined roof is not recommended for strong wind zones.

Mounting frame size:

A mounting frame is a single table of mounting structure where PV modules are fixed either in landscape or portrait position. As the design wind load is proportionate to the projected area normal to the wind, selection of mounting frame size will decide wind pressure on the PV array. Since Assam is situated in very high damage risk wind zones, it is of utmost importance to select the right mounting frame size and module position to minimize wind load and keep the solar plant safe. It is recommended that, for an RCC flat surface, not more than one module in landscape (parallel to the roof surface) should be installed in a racked mounting structure. Portrait position of module shall be avoided to minimize effective wind area. The recommended frame size for a flat roof shall be 1 x 1 (landscape) and it shall not be higher than 1 x 5 (landscape) in a single row. In case of a inclined roof, modules will be installed in the same tilt angle as that of the roof. No racking of modules shall be permitted on the inclined roof. The recommended frame size for an inclined roof shall be 1 x 1 (portrait or landscape) and it shall not be higher than 1 x 5 (landscape) or 1 x 10 (portrait) in a single row.

Determining space between two rows:

Space between two rows can be determined by analyzing the sun's position for winter solstice (21st December) as explained in the procedures for shadow analysis. In this case, the object that will create shadow is the PV array (row) on the south. The minimum space between two rows shall be higher than maximum length of the shadow at desired time of the day says, 8.00am in the morning and 3.00pm in the afternoon (local time) for lowest position of sun on 21st December. The length of the shadow will be determined by the azimuth and altitude of the sun during the desired time and differential height of the lowest point of the row in the north and highest point of the row in the south.

Step 3: Installation and testing of structure earthing system

After installation of module mounting structure, the next step is to provide a continuous equipotential bond between mounting structure and module frames. Following procedures to be followed:

(1) Verify the earthing conductor routing plan.

(2) Prepare earth terminal bar/conductor, lugs, clamps, earthing rod, and eardrawing.s per drawing;

(3) Ensure all module frames and each part of the mounting structure are electrically bonded; (4) Use proper WEEB for bonding.

(5) Find the best location for earthing pit where soil is wet, and resistivity is least;

(6) Attach the earthing terminal bar /wire with earthing rod.

(7) Connect terminal bar to structure.

(8) Ensure all the connections are neat and tight.

(9) Test earthing continuity and resistance of earth electrode after installation

The conductor used to earth the exposed metallic frames of the PV array shall have a minimum size of 6mm^2 copper or equivalent if there is no lightning system installed for the system. When a lightning protection system is installed, the minimum size of the conductor shall be 16mm2 copper or equivalent. PV array bonding conductors should run as close to the positive and negative PV array and or sub-array conductors as possible to reduce induced voltages due to lightning.

Procedure for measurement of earthing continuity and earth electrode resistance using earth resistance tester – Follow in sequence

(1) Short the P1 and E1 terminal of the Earth resistance tester.

(2) Connect the electrode under test to E1 terminal of earth resistance tester.

(3) Using a hammer, dig an electrode at a distance (D) of minimum 30 meter from the test Electrode.

(4) Connect this electrode to E2 terminal of earth resistance tester.

(5) Using a hammer, dig another electrode in between both the electrodes at 50% of D.

(6) Connect this electrode to P2 of the terminal.

(7) Take reading by rotating the handle of Earth resistance tester or press push button.

(8) Repeat above procedure by changing the location of middle electrode to 40% and 60% of D;

(9) To get the resistance of electrode, take mean of these three readings.

Step 4: Installation of PV modules

Modules should be installed after the earthing system of structure is completely constructed. It is important for the installer to know properly about handling, packaging and storage of PV modules so that modules do not get damaged during the process of installation.

Module Installation:

- PV modules can be fixed either by bolt method or by the clamp method.
- Understand and follow manufacturer installation manual and recommendations.
- Use personnel safety equipment while installing the modules.
- Use of insulated tools and gloves while working with module.
- Do not step on the PV module as this will damage to the solar cells inside the module
- Ensure electrical connectors are well protected from ingression of water and dust.

- Do not install/ handle PV modules under gusty winds and if there is rain.
- Use appropriate tools and equipment provided/ recommended by manufacturer.
- Do NOT connect the modules in the strings (connect in series)

Step 5: Earthing of PV Module Frames

After physical installation, PV module frames are to be bonded together and connected to main earthing conductor of the mounting structure. The conductor used to earth the exposed metallic frames of the PV array shall have a minimum size of 6 mm2 copper or equivalent. PV array bonding conductors shall run as close to the positive and negative PV array and or sub-array conductors as possible to reduce induced voltages due to lightning. The earthing conductor must be properly fastened to the module frame to ensure good electrical contact. PV module frames have anodised coating which is an aluminium oxide, and it works as insulation. Therefore, appropriate means should be employed, which will crash the aluminium oxide coating and establish electrical bond between PV module frames and the structure.

Step 6: DC cabling

It is important to minimize voltage drop loss in the cables for the desired performance of solar PV systems. Ensure that aggregate voltage drop in all DC cables is less than 3% as recommended by IEC 62548 PV array design requirements.

Precautions to take while wiring modules:

- Only a trained and qualified installer should perform all wiring.
- Use stainless steel clamp or UV protected cable tie to fix cables.
- DO NOT connect all the module in series to avoid high DC voltage.
- Final connection will be done when the system is ready for commissioning.
- Ensure electrical connectors are well protected against corrosion and soiling.
- Ensure that connectors are corrosion free, cleaned with absolutely no gaps between the contacts.
- DO NOT allow any inflammable liquids/gases near installation area.

Follow the steps below in sequence for module wiring or stringing:

(1) Review the DC cable wiring diagram.

(2) Review module interconnection (string or series) diagram.

(3) Check that there isn't any bare cable in the module wire.

(4) Connect DC cable connector (MC4 or equivalent) properly with the crimping tool.

(5) Connect number of modules in series in accordance with the wiring diagram provided; (6) Attach the cables with cable tie wraps to the module frame and/or rails.

(7) Ensure minimum looping in cable.

(8) Ensure NO cable is hanging loose.

(9) Label the terminals with "+" and "-" sign using cable tags.

Step 7: AC cabling and installation of inverter

When DC cables and DC combiner boxes are installed, the next step is to install AC cables and the inverter. Ensure that total voltage drop in all AC cables is less than 2% according to IEC 62548.

Procedures to follow:

(1) Install the conduit/ cable tray.

(2) Pull the conductors through conduit or cable tray.

(3) Leave excess conductor or cable near each equipment terminal.

(4) Read inverter installation and operation manual carefully.

(5) Ensure that there is adequate ventilation for the inverter.

(6) Ensure that no direct sunlight falls on the inverter.

(7) Mount the inverter with accessories provided by the manufacturer.

(8) Ensure there is no grid supply to the inverter.

(9) Complete the installation from the inverter to the AC isolator and energy.

(10) Install the earthing connection as per inverter installation manual.

(11) Tighten the cable glands using appropriate tools

IRRIGATION AND DRAINAGE ENGINEERING (IDE)

Skill Set (IDE) 1 : Technical skills in installation and maintenance of micro-irrigation

Skills to impart : Design, installation and maintenance of drip irrigation system.

Tools and materials : Portable drip irrigation kit; display board of micro irrigation components, filters etc. turbidity meter

Drip Irrigation and working principle.

Drip irrigation, which is also known as a trickle irrigation system, is a modern way to water plants. It uses a network of low-pressure lines to slowly apply water to the soil near the roots of plants through small devices called emitters or drippers. Drip irrigation is a method that focuses on watering only the specific area around the roots of the crop, rather than covering the entire surface of the ground where the crop is cultivated. The emission sites facilitate the movement of water through the soil via capillarity and gravity. The soil moisture content in the area where the crop roots are located is kept at levels that are very close to the best possible values in order to promote the best possible growth and production of the crop. The conventional drip irrigation technique primarily necessitates a power source and is employed for irrigating expansive agricultural areas.

Types of drip irrigation system

i) Surface drip: This method involves the placement of laterals and emitters directly on the surface of the soil. It is a prevalent form of drip irrigation system that is commonly employed for crops that are spread far apart, but it may also be effectively utilized for row crops. Typically, the discharge rates for single outlet point source emitters are below 12 l/h, while for line source emitters, they are below 12 l/h-m. The benefits of surface drip irrigation include easy installation, inspection, cleaning, and replacement of emitters.

ii) Subsurface drip: Subsurface drip irrigation involves burying laterals with drippers into the earth. Water is delivered gradually beneath the soil surface using emitters that have discharge rates similar to those of surface drip systems. This method is primarily utilized for densely planted row crops, however it can also be employed for tiny fruit crops. The primary benefit of this technology is the reduction of evaporation losses, minimal disruption to cultivation or cultural practices, and the potential for a longer operational lifespan.

iii) Inline Drip Irrigation system: When using inline drip irrigation, the drippers are pre-inserted at predetermined intervals throughout the pipe's length during the extrusion process. Therefore, for optimal performance, inline drippers work best with plants that are evenly spaced, avoiding numerous connections with simple pipe for areas that do not need irrigation. Inline drippers can be installed fast and easily because the dripper insertion process is completed during the extrusion process. Once one end of the pipe is linked to a water supply, the dripper will start to drip consistently. Because of this, they are the perfect option for vast farms and crop fields where the plants are evenly spaced and where the drip irrigation system's size necessitates an economical installation and maintenance procedure.

iv) Online drip irrigation: In online drip irrigation, the PE pipe is delivered without drippers and must be manually connected to the exterior wall of the pipe. This method has the advantage of being able to work with plants that are not evenly spaced since drippers are manually inserted precisely at the required point. Another advantage is that because the drippers are accessible from the outside of the pipe, several online drip emitter types allow for manual adjustment of each dripper flow, as well as the

ability to clean or readily replace a dripper if necessary. These features typically allow for more dripper control and a more personalized experience. The disadvantage of the online kind is that inserting the drippers is a difficult job, which raises the cost and restricts the size of the irrigation system installation. As a result, online drip emitters are most commonly employed in greenhouses, house gardens, and other small-scale gardening applications where the additional cost of physical labour can be justified.

Crops grown using the drip irrigation system

Sr. No	Name of the crops grown with drip irrigation
1.	**Vegetables:** Tomato, Chilly, Capsicum, Cabbage Cauliflower, Onion, Okra, Brinjal, Bitter gourd, Ridge gourd, Cucumber, Green peas, Spinach, Pumpkin, etc.
2.	**Cash crops:** Cotton, Arecanut, Coffee, Tea, Sugarcane, Rubber, Strawberry, Spices, Turmeric
3.	**Flowers:** Rose, Carnation, Gerbera, Anthurim, Orchids, Jasmine, Lily, Mogra Dahlia, Marigold.
4.	**Orchard crops:** Grapes, Banana, Pomegranate, Orange, Citrus, Mango, Lemon, Custard apple, Sapota, Guava, Pineapple, Papaya etc.
5.	**Oil-seeds:** Groundnut, Sunflower, Coconut, Oil palm etc.
6.	**Forest trees:** Teakwood, Bamboo, Casurina, Eucalyptus

Essential Information Needed for Drip Irrigation System

1. Survey of land
2. Type of crop
3. Soil type
4. Land slope
5. Climatic records
6. Source of water and water quality

Major components of drip irrigation system and their functions:

Main line: It is made of rigid PVC or HDPE pipe and the main line usually ranges from 50 mm to 90 mm with a pressure rating of 4 to 10 kg/cm^2. These are generally placed 60 to 90 cm below the ground. It carries water to the sub-main line.

Submain: The submain line is made of PVC material Carries water from the mainline to the laterals. They are generally buried in the ground below 45 cm to 60 cm.

Laterals: Lateral distributes water to the emitter, delivering water directly to the root zone. These are small PVC tubing made of LDPE or LLPPE of 12mm, 16mm, or 20 mm diameter. Black color is preferred to avoid algae growth and damage due to ultraviolet radiation. Wall thickness vary from 1 to 3 mm with pressure rating of 2.5 kg/cm^2 lateral pipes should be flexible, non-corrosive and resistant to ultra-violet (UV) rays. LLDPE gives better protection than PDPE. Lateral is connected to a sub-main or main pipe usually through a manifold. Drippers are fitted on laterals.

Manifold: The manifold or header connects the main line to the laterals. Pressure loss in manifolds depends on the topography, pressure loss in the laterals, and the total variation allowed in the design of emitters.

Drippers: Drippers are generally made from polypropylene or polyethylene material. The function of the dripper is to emit water in the form of drops or continuous flow to the soil. Drippers are fitted on the lateral line or inside the lateral line.

Screen filters: This is most common type of filters used in drip irrigation system. The screens are usually cylindrical in shape and are made of non-corrosive metal or plastic material.

Flow control valve: Ball valves made of rigid PVC or HDPE materials are used.

Flush valve: It is provided at the end of each sub-main to flush out the water and dirt accumulated at the end of sub-main.

Air release valve: It is provided at the highest point in the main line to release the entrapped air during the start of the system and to break the vacuum during the shutoff. It is also provided at sub main if sub main length is longer.

Non-return valve: It is used to prevent damage of the pump from the backflow of water (Water hammer) in the rising main line of the drip irrigation system ion of drip irrigation.

Fitting accessories: Various fitting accessories are required during installation of drip irrigation like elbow, bends, socket, reducer, Tee, end plug, washer, nipple, bends polyjoiner, Take off Grommet as shown in figure.

Drip Irrigation HDPE Fitting Accessories

Steps in Design of Drip System at Farmers field

Estimation of design parameters for proposed micro irrigation: Based on the collected information on cropping pattern, soil analysis, water quality and availability for irrigation and the topographical conditions of project site, theoretical layout of the field may be decided. Following design parameters are considered and standard equations are used for selection of above design parameters:

1. Selection of emitter and flow rate
2. Selection of lateral length and size
3. Selection of submain and main pipe size
4. Head loss calculation
5. Selection of pump

Selection of Dripper: The selection of type and number of drippers per plant is based on Peak water requirement of crop and soil type. Dripper selection would meet the following points.

- It should be compact, serviceable and inexpensive to keep the system cost low.
- It should have relatively low discharge to keep the system cost low.
- It would not vary significantly with pressure this will give good uniformity of distribution.

Selection and Design of Lateral: The lateral carries water from sub –main and feeds to drippers. One lateral for each row of orchard plants and one lateral for two rows of vegetables is used. The size and length of lateral is decided by using poly plots.

Selection and Design of Sub-main: These include the PVC pipes having specifications such as 40 mm X 8 kg/cm^2, 50 mm X 6kg/cm^2, 63 mm X 4 kg/cm^2 , 75 mm X 4 kg/cm^2 can be used as a Submain.

Design of Mainline: The size of mainline is decided by referring to the PVC friction loss chart, All PVC pipes for irrigation are outer diameter controlled. The pressure rating of pipe is determined by the PVC material used and the dimension ratio. They are generally available in class 1 to 4 corresponding to 2.5, 4.6 and 10 kg /cm^2.

Section Pump: It depends on the total head calculation as given below.

Total head= (Suction + Delivery) + filter losses + Mainline loss + Operating of drip irrigation system + fruiting loss + Venturi head+ elevation difference.

The suction head is the vertical distance between water level to the center of the pump. The delivery head is the vertical distance between the centres of pump to the outlet. Filter losses are assumed to be 2 m for screen filter and 4m for sand plus screen filter. Operating pressure is approximately 1kg/cm^2 at the last dripper of lateral.

Filter loss is assumed to be 2m, venturi loss assumed to be 5 m and elevation is the upward slope of ground. Whereas the downward slope of the mainline and plot should be considered while calculating the total head of the pump.

Installation of gravity drip irrigation system in terraced field

The gravity fed low head micro irrigation system installed as per the design consideration in the CAEPHT, Sikkim.

Performance evaluation of drip irrigation syst The procedure of hydraulic design consists of

- Knowing the operating pressure of emitters.
- Finding out the allowable head loss in lateral and sub main.
- Finding out the lateral and sub main discharge
- Finding out the diameter and length of the lateral such that the head loss in the lateral is within allowable limits for the given layout. For this purpose, finding out the head loss by Hazen William or Darcy-Wesibach formula for different combinations of diameter and length and selecting the suitable combination by trial and error method
- Repeating the procedure for the sub-main
- Find out the diameter of the main so that the velocity is within the allowable limit or find out the head loss in main for the specified diameter of the main. The length of the main is the distance of the field from the water source.

OPERATIONAL REQUIREMENT OF DRIP IRRIGATION SYSTEM

The following are the operational requirements of drip irrigation system:

1. Irrigation must be frequent: This means that the irrigation must be given daily or alternate days during the measure growing seasons. Plants deplete water faster in small root volumes wetted. Rate of water movement by capillarity decreases rapidly as the soil dries and becomes zero if the soil cracks.
2. Water should be applied slowly: It means that, it can be absorbed and not flow as runoff from application point. Runoff and ponding should be avoided.
3. Application duration should be accurate: The duration of water application should be time based to apply the water consumed since the previous irrigation. It may range between 1 and 16 hours and should be continuous. If more than 16 out of 24 hours are needed regularly, the number of emitters per plant should be increased. Duration should not extend beyond the time when ponding or runoff starts, this can be avoided by stopping the water and starting again at later time.
4. Measured amount of water should be applied: Amount of water should be applied according to one measured or carefully absorbed soil-water condition that reveals the balance between additions and withdrawals. Evaporation measurements can be used if suitable corrected factors for plant size are available.
5. Filter should be cleaned periodically: Sand and screen filters should be cleaned periodically by built-in flushing for proper functioning of the drip system. Depending on water quality and filter size, this may be weekly, twice a week or twice a month. Once in a month, the end cap of each lateral line should be released to flush out accumulated sediments deposited in the laterals.
6. Discharge rate of emitter should be checked: Emitters should be checked visually each week for correct flow. As their performance builds confidence, the intervals between checking may be increased. Take precise measurement at least twice each year by catching the flow from a number of emitters in a calibrated cylinder for exactly ten minutes. Problems of emitter performance or pressure control in lateral lines are reveals by such measurements.
7. Water pressure at the inlet and outlet of the filters and in the lateral must be measured: Water pressure in the lateral at the emitter affects the output of most emitters. Pressure compensating emitters maintain a constant outflow.
8. Pressure control in the distribution system is generally necessary and is accomplished by placing laterals as nearly as possible on the contour and by including an adjustment valve at the connection of each lateral to the main on sloping field. The pressure at this adjustment valves should be checked periodically, and valve adjusted as needed.

Gravity drip irrigation system for small vegetable growers

It is the energy saving method in which the water is channelized and distributed through network of small diameter PVC pipes through gravity and directly applied in the root zone of crop, through emitting device at a low pressure. Elevation difference between the land surfaces is suitable for the operation of gravity fed drip irrigation for the small and the marginal farmers. Several studies conducted on the field crops have reported the more saving in water and increase in the yield with the use of drip and sprinkler irrigation system. General Layout of Low Cost Drip Irrigation System is shown below

Major components of gravity fed drip Irrigation system are:

1)Storage tank, 2) Main line, 3) Sub main line, 4) Laterals, 5) Drippers, 6)Filter, and 7) Fitting accessories

Maintenance of drip irrigation system:

Drip irrigation system has proved its utility in water saving and increase in yield as compared to traditional surface methods but due to technical knowhow and initial investment prevents the farmers for its adoption.

General points to note after installation and commissioned in the field.

1. Start the system and see for any leakage through the entire pipeline i.e. main, sub main, lateral and all joints, and valves.
2. Check the operating pressure of the drip system or adjust according to the requirement by controlling the bypass valve.
3. Check the position of the drippers; locate it properly near to the plant stem. See the oozing of water from the emitter by observing the wetting pattern near the plant.

Clogging factors can be classified into three main categories:

- Inorganic suspended solids
- Organic (biological) matter (algae and bacteria)
- Sediments generated by chemical reactions.

Clean water is the prime requirement for drip irrigation system, presence of impurities in the water can be classified into

- Presence of large particles in the water supply
- Presence of high silt and clay loads in the water supply
- Growth of bacterial slime in the system
- Growth of algae within the water supply or the system

Precipitation of iron, sulphur, or calcium carbonates

Cleaning and maintenance of filters:

Filter the heart of the drip irrigation system. The proper function of the entire system depends on the smooth function of filter. If sand filter is installed, then back flushing of filter for five minutes is required to remove the foreign impurities inside the filter. Looking to the water condition it can be done as suggested below.

- Very dirty water: every day
- Dirty water: 3-4 days interval
- Reasonably good water: 9 days interval
- Good quality water: 15 days interval

Screen filter or Disc filter: Open the drain valve of the filter so that dirt and slit will flush out. When the system is off, open the filter lid and take out the filter element. Clean it with flowing water. Fit it properly.

Flushing of sub main and lateral: sometimes dirt or algae accumulate in the pipe. By opening flush valve sub main can be cleaned. Lateral can be flushed by opening end caps.

Cleaning of drippers: It can be done manually or by chemical treatment of acid like Hcl or chlorine which is essential to remove the precipitation of insoluble salt from the orifice or inside the internal parts.

Skill Set (IDE) 2 : Technical skill for development IoT based micro irrigation system

Skills to impart : IoT based micro irrigation system.

Tools and materials : Micro controller, multimeter, solar panel, solenoid valve

The Internet of Things (IoT) popularized the idea of smart devices, which are meant to connect the physical and digital worlds to create an interconnected smart world. IoT-based systems often include devices that are placed in a certain location to perform various tasks like detection, observation, control, and action. The majority of systems are separated into various levels that require significant work to be done.

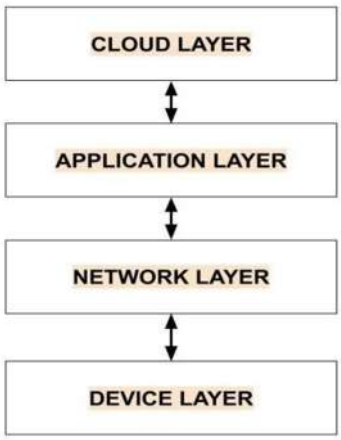


Fig. Basic layers of IoT-based irrigation

It enables users to communicate with IoT-based systems by instantaneously controlling equipment and supporting consumers in reaching a decision. Depending on the application for later use, the data is kept in different types of cloud databases.

Concept of IoT based drip irrigation system.

The Internet of Things (IoT) is a conceptual framework that facilitates the connection and integration of intelligence into devices, enabling a network of interactions between machines, individuals, objects, and combinations thereof. IoT represents an automated system that establishes a universal network for interconnecting everyday physical objects. These objects are equipped with uniquely identifiable devices, incorporating sensors, software, electronics, and actuators, allowing them to connect and share data seamlessly. In the contemporary era, we witness an abundance of interconnected technological devices that possess the capability to communicate, perceive their surroundings, and exchange information across both public and private IP networks. For researchers today, the field of the Internet of Things (IoT) holds immense significance and innovation. Soon, the Internet of Things is poised to become an integral element of modern technology, promising to enable smart and digital living by facilitating communication among various heterogeneous objects in our surroundings. Leveraging software, sensors, actuators, network connectivity, and other essential components, the Internet of Things aims to establish connections among diverse smart devices, enabling them to both exchange and gather data.

Components required for IoT based automatic drip irrigation system

Water flow to the field is managed by a solar-powered battery-operated IoT-enabled solenoid valve. This valve is connected wirelessly to soil moisture sensors positioned within the polyhouse, where

cabbage crops are grown. The valve's opening and closing are determined by predefined soil moisture sensor readings, allowing for real-time irrigation control. Detailed information about the hardware components within the controller unit can be found in Table 1.

Table 1: Specification and description of hardware

Sl. No.	Module	Specification	Function
1.	Arduino UNO	Operating voltage (logic level): 5 V Digital I/O Pins:14 (of which 6 provide PWM output) Analog Input Pins: 8 DC current per I/O Pin: 40 mA Flash memory: 32 KB (of which 2KB used by bootloader) SRAM: 2 KB, EEPROM: 1 KB Clock speed: 16	Open-source microcontroller board on ATmega328P
2.	Arduino MEGA	Digital I/O pins-54, Analog inputs-16 pins, PWM outputs-14 pin Hardware serial ports (UARTs) – 4 Crystal Oscillator-16 MHz, ICSP header, Power jack, USB connection	microcontroller board based on the ATmega 2560 control a singular function in a device
3.	Wi Fi Module	Frequency- 2.4 to 2.5 GHz	To send data to a gateway
4.	Air Quality Sensor	3 to 5V power and I/O. 2.5mA max current	Detection of harmful gases
5.	DHT-11 Sensor	3 to 5V power and I/O; 2.5mA max current; 20-80% humidity readings with 5% accuracy, 0-50 °C temperature readings +-2 °C accuracy.	Monitoring the ambient temperature and humidity of a given area
6.	IR Sensor	Operating Voltage-3.3 ~ 5 VDC Distance Measuring Range-2 ~ 30 cm	To detect the motion of an object
7.	Soil Moisture Sensor	Operating Voltage-3.3 ~ 5 VDC	determines the amount of soil moisture by measuring changes in capacitance to determine the water content of the soil
8.	Voltage Converter	Input voltage - 3.2 V–40 V DC To convert voltage from 12 V to 5 V Output voltage - 1.25 V–35 V DC	To convert voltage from 12 V to 5 V

9.	Solenoid Valve	12V DC	Opening and closing of valve
10.	Solar Panel	Power:10 W; Output: 12 V	To recharge 12 V battery
11.	Relay	Normal Voltage -5V DC Normal Current - 70mA	Automatic switch to control a high-current using a low-current signal
12.	GSM Module	SIM 7670C 4G LTE Bands: GSM 850 MHz, EGSM 900 MHz, DCS 1800 MHz, PCS 1900 MHz 5 V interface, Voltage Supply Required- 9VDC to 12VDC with at least 2A Peak Current Capability	To connect with the cloud server
13.	Battery	12V,7Ah Standby use 13.6V-13.8V	It will be charged by Solar Energy and will O/P the power to the system
14.	LCD Display	4.5V,1mA	For displaying purpose
15.	Jumper Wire	M-M, F-F, M-F, F-M	For connection

Gravity fed IoT based drip irrigation for terraced topography.

Terraced fields with regular shapes (width and length) having terrace width not less than 2 m is effectively used for the installation of gravity fed IoT based drip irrigation system. Cultivation of a variety of vegetable crops on terraces is possible with the gravity-fed IoT-based drip irrigation system. The main and sub main lines of PVC pipe are used during installation. The water storage tank is kept at the top terrace. Lateral lines of 12 mm or 16mm diameter pipe with inline drippers are used in the system. The system is operated using ball valve.

Maintenance of IoT-based drip irrigation system:

IoT-based Drip irrigation system has proved its utility in water saving and increase in yield as compared to traditional surface methods due to its technical know-how and initial investment of the farmers for its adoption. Proper maintenance of the system increases its efficiency and gives better economic results.

General points to note after installation and commissioned in the field.

1. Start the system and see for any leakage through the entire pipeline i.e. main, sub-main, lateral, and all joints, and valves.
2. Check the operating pressure of the drip system or adjust it according to the requirement by controlling the bypass valve.
3. Check the position of the drippers; locate the soil moisture sensor properly near to the plant stem. See the oozing of water from the emitter by observing the wetting pattern near the plant.

Clean water is the prime requirement for drip irrigation systems, presence of impurities in the water can be classified into

- Presence of large particles in the water supply
- Presence of high silt and clay loads in the water supply
- Growth of bacterial slime in the system
- Growth of algae within the water supply or the system
- Precipitation of iron, sulphur, or calcium carbonates

VETERINARY SCIENCE

Skill set (VETY) 1: Casting of horse

Purpose of casting:

The casting of an animal means, throwing the animal down and confine him completely for a certain operation. The casting of animals is necessary for major operations on the ventral surface of the body or on the extremities of an animal so that: -

- A surgeon may work safely and aseptically.
- The animal may not injure himself in his effort to escape.

Materials required:

- Halter, bridle, head collar, head rope and watering bit.

Approaching of horse:

- Approach the horse always from the left side, called near side.
- Handle from front and never from behind i.e. handle head or neck first.
- Never carry any stick, because it frightens the animal.
- Pat the animal and speak to him in kind words.
- Be careful and do not be nervous while approaching strange horse. The animal should not know that you are afraid of him.
- Do not go towards the back side of the house, unless a fore leg has been raised up, because he can kick backwards.
- It is helpful to know the temperament and other peculiarities of the house from his attendant.

Casting procedure:

- At the signal to the men to pull the casting rope, the man at the head is instructed to back the horse vigorously, at the same time the man holding the double rope pulls the horse over.
- Backing the horse brings his four feet close together and as he loses his balance he falls over on his side.
- At this stage there is usually vigorous struggling and the men on casting rope must be instructed to continue pulling until all four feet are brought together and the chain has been pulled fully through the metal loops of the hobbles.
- This chain is prevented from running back through the loops by the spring ‘D’ catch which is slipped through the link nearest to the hobbles.
- The head and neck must be kept straight. Man holding the head should sit on the neck and the spare man on the hips when the animal falls down on the ground.

Casting process:

Take a 50-foot-long rope, lay it out on the ground, double it, and make a loop in the centre. The loop should be made with a figure of an "8" knot which will lie flat against the breast and so avoid a bruise, the circumference of the loop may be about three feet. Gather up each free end in a coil to prevent its becoming entangled around the animal's legs.

- Place the loop over the animal's head to rest in front of the withers.
- Pass the coiled ends of the long rope between the fore legs and round the hind legs to rest above the hocks. This ensures that if the animal kicks the rope will remain in position, otherwise the horse may kick his feet clear of rope with great ease.
- The coiled ends of the rope may be passed either from outside inward or from inside outward, the latter procedure being safer for the person applying the ropes.
- The ends are then brought forward underneath the first part of the rope and through the neck loop.
- One end of the rope is held by two men well in advance of the horse and the other end by two men well behind him.
- The loops of rope around the hocks are then allowed to slip down to the pastern and if the twitch has been used it is removed.
- When the order for the pull is given, a man at the head backs the horse, as the hind feet are pulled forward, the animal is forced into a sitting position from which he can easily be turned over to the required side.
- It is better to use double rope in the uppermost foreleg to facilitate the casting of the animal on the desired side.
- The upper hind leg is drawn right up to the shoulder and two or three half hitches are taken round the pastern.
- The foreleg is then similarly secured by half hitches round the pastern close to the hind leg.
- The animal is then turned over and the other hind and fore legs are dealt with in a similar manner.
- Application of stable bandages on each leg is essential before the use of ropes.
- This method can also be applied for cattle, large sows, but with these animals the long rope should pass above the hocks and not round the pasterns.
- Demonstration of casting of horse is to be given to the class by both methods.

Skill Set (VETY) 2 : Preparation of horse for show and judging

Objective:

- A Horse show is a judged exhibition of horses and ponies. Many different horse breeds and equestrian disciplines hold competitions worldwide, from local to the international levels.
- Most shows consist of a series of different performances, called classes, wherein a group of horses with similar training or characteristics compete against one another for awards and, often, prize money.

There are two types of shows:

a. Horseshow: In horse show breed characteristics, soundness, and confirmation is more accounted.

b. Fancy show: In fancy shows, they should be more decorative and attractive.

Preparation of horse for the show:

- The horse must be appropriately groomed and clipped, as the exhibitor is being judged on the ability to fit and show a horse "in hand".
- The horse must be prepared months ahead of the event by being provided with good nutrition to develop a healthy, shiny coat.
- Their hooves should be trimmed regularly by a farrier and kept balanced, smooth, and neat.
- It should be brushed and otherwise groomed frequently to further promote a shiny coat and good overall health.
- The horse should also be exercised regularly, either in hand or under saddle, to develop good muscle tone.
- The day before the show, the horse should be bathed and hair on its mane, tail, legs and head trimmed or clipped to meet the style standard for the particular breed of horse.
- Often special conditioners are used on the hair to make it extra shiny or silky.
- It is very important for competitors to be very familiar with the most minute grooming and style details for the breed of horse and style of tack and clothing they choose to use in the ring.
- A style required by one breed association may be considered illegal by another.
- Depending on the breed of the horse and the style of tack used, the main might be braided, left loose, or "banded" (having small rubber bands put around small sections of a short mane at the rotor to help it lay down).
- Horses shown with loose, flowing manes sometimes have their manes put into 5 or 6 large braids the night before, taken out just before the class and brushed to give an attractive, wavy appearance.
- Horses required to have naturally long tails sometimes have them kept "up" when not showing, the long hairs braided up to the bottom of the dock, then the braid rolled up, with a bandage or old sock put around the hair to keep it from breaking off and to keep the tail clean. When taken down and brushed out, a tail kept in this manner is wavy and flowing in the ring. If kept up at all other times, a tail may grow so long that it drags on the ground.

- On the day of the show, shortly before it goes into the ring, the horse is not only groomed to remove every possible speck of dirt, but it will usually have polish applied to its hooves, a light oil or conditioner placed on its muzzle, around the eyes, and other strategic areas of the head to accent its best features, and usually have a light coat dressing sprayed on its entire body for a bit of last-minute shine.

Equipment and clothing:

- A horse can be shown under saddle in either English or Western equipment, the handler may choose their style of equipment, but it cannot be mixed between the two styles.
- The horse shown western style is required to wear a halter and be handled with a lead shank. This is usually a well-fitted leather halter with a slim leather lead shank.
- The horse shown hunter style wears a proper English style bridle, with the handler either leading the horse by the reins or with a lead shank attached to the bit.
- The horse shown saddle seat style may, depending on breed, be shown either in a modified form of the bridle used in riding classes or in an extremely thin, refined leather or leather like halter.
- The exhibitor, male or female, must wear pants, a shirt with a tie or brooch, and boots. Some show rules require a hat. Gloves are optional, but usually worn by winning exhibitors because they provide a better grip on the lead shank and give a polished look.

Skill Set (VETY) 3: Collection of blood from animals

Materials required:

Needle and syringe, vial with anticoagulant, spirit, cotton, etc.

Procedure:

- Clip the area from where blood is to be collected. The sites for the collection of blood in different species of domestic animals are given below in the table:

Animal Species	Site	Needle gauge	Needle length(inch)
Cow, Buffalo, Horse	Jugular vein	16-18	1.5-2
Sheep, Goat	Jugular vein	18-20	1.5-2
Pig	Anterior venacava	20	2.5-4
Dog	Cephalic vein/Jugular vein/Saphenous vein	20-22	1.5
Cat	Cephalic vein/Jugular vein/femoral vein	22-25	1
Rabbit, Guinea pig	Ear vein/ cardiac puncture	18	3
Monkey	Femoral vein	22-26	0.75-1
Rat, Mouse	Orbital sinus	Micro blood collecting tube	1
Birds	Wing vein	20-22	1

- Apply the spirit on the site and allow it to dry and raise the vein by the pressure.
- Then insert or stab the needle in the vein and collect the blood in the syringe or vial as per the requirement.
- If collected in syringe, remove from the syringe and transfer blood in the anticoagulant vial, close the vial and make gentle rotator movement so that the anticoagulant gets dissolved and uniformly mixed with blood.

Preservation of sample:

- After collection of blood samples if it is not to be examined, then we preserve the samples.
- If we require serum, blood is allowed to form fibrin clot without anticoagulant which is then separated by centrifugation at 3000 RPM for 15 minutes. Collect the supernatant as serum.
- If we need whole blood or plasma, then we preserve the blood sample by mixing with the anticoagulants.

Anticoagulant:

It is a substance that prevents the clotting of blood by removing the calcium, inactivating thrombin and thromboplastin, or by removing fibrin i.e. defibrination. This preservation for a short period can be done at a refrigeration temperature (4^0C) and for a longer period in a deep freeze.

Different anticoagulants used are:

1. **Ethylene Di-amine Tetra-Acetate (EDTA)**: It is available as sodium or potassium salts and prevents clotting by chelating calcium. The optimum concentration used is one mg per ml of the blood.

Advantages:

- It is the preferred anticoagulant for routine cell count and preparation of blood smears for microscopic availability.
- Cheap and easily available.
- Gets dissolved in blood readily and becomes active immediately.

2. Sodium Citrate: It prevents clotting by chelating calcium ions. It is used as 1 part of 3.8% aqueous solution citrate and 9 parts of the blood

Advantages:

- Used for blood transfusion.
- Good for complete blood cell counts.

3. Acid citrate Dextrose (ACD)

It is a specialized anticoagulant mixture used for blood transfusion.

Composition	Solutions A	Solutions B	Solution C
Tri–sodium citrate	22.0 gm	13.2 gm	Composition given below
Citric acid	8.0 gm	4.8 gm	
Dextrose	25.0 gm	14.7 gm	
Distilled water to make	1000 ml	1000 ml	

Solution C:

Disodium citrate	2 gm
Dextrose	3 gm
Distilled water to make volume	125 ml

The optimum amount used for this ACD mixture is:

Solution A	75 ml per 500 ml of blood
Solution B	125 ml per 450 ml of blood
Solution C	125 ml per 420 ml of blood

Note: The survival rate of cells is about 70% after 21 days of storage at 4^{o}C in all these three solutions.

4. Oxalate salts (Heller's and Paul's mixture):

Composition: 3 parts of ammonium oxalate and 2 parts of potassium oxalate. It prevents clotting by chelating calcium ions. Optimum concentration used is 0.2 mg of oxalate salts per ml of the blood.

Advantages:

- The oxalates are most commonly used anticoagulants for haematology because ammoniswelllate swells the erythrocytes. And potassium oxalate shrinks them. So a mixture of these in the proportion of 60:40 is used to keep in normal state.
- Cheap and easily available.
- Plasma can be used for biochemical estimation except Blood Urea Nitrogen (BUN)

Disadvantages:

- Keeping quality is poor.
- Oxalates cause nuclear decentration of leucocytes.
- Not suitable for blood transfusion.
- Increases erythrocytes sedimentation rate (ESR) so not good for ESR.

5. Heparin

Heparin is a natural anticoagulant occurring in liver and various other body tissues Heparin acts by neutralizing the action of thrombin by making a complex with anti-thrombin-III. Optimum concentration used is 1% heparin solution as 0.1ml/5.0 ml of blood.

Advantage:

- Good for biochemical estimations and blood gas analysis.

Disadvantages:

- It is costly.
- Interfere in staining of leucocytes so not good for leucocytes counts.

Skill Set (VETY) 4: Estimation of hemoglobin concentration

Hemoglobin:

Hemoglobin (Hb) is the main component of the erythrocyte which is a conjugated protein and serves to transport CO_2 and O_2 in the body. Hemoglobin is estimated by following methods:

1. Sahli's Hemoglobinometer
2. Spencer Hemoglobinometer
3. Cyanmet Hemoglobin Method

Sahli's hemoglobinometer method:

Principle:

A measured volume of blood is converted to acid hematin with dilute hydrochloric acid and the hematin solution is diluted dropwise until it matches with yellow- glass standards of the haemoglobinometer and the reading is noted.

Apparatus & reagents required

Sahli's haemoglobinometer, hemoglobin pipette and stirrer, 0.1N HCI, distilled water and blood sample.

Procedure:

- Take 4-5 drops of 0.1N HCL in the calibrated tube of Sahli's hemoglobinometer and then add exactly 20µl (0.02ml) of blood sample to the hemoglobinometer tube with the help of haemoglobin pipette and mix properly with the help of stirrer.
- Allow the tube to stand for 10 minutes for the formation of acid hematin.
- Then dilute the hematin solution with distilled water till the colour matches with glass standards and read the lower meniscus while taking the readings, this will give Hb concentration as gm per 100 ml of blood or gm% or gm per dl of blood.

Advantages of Sahli's method:

- Low cost.
- Being portable can be taken in field conditions.
- Give immediate results.

Precautions:

1. Take exactly 0.02 ml (20µl) of blood and wipe excess of blood adhering to outside of pipette,
2. Concentration of HCI should be exactly 0.1N.
3. There should be proper mixing of the acid and blood for proper formation of acid hematin.
4. Properly well mixed blood should be taken.
5. There should not be any air bubble in the pipette.
6. Read lower meniscus while taking the reading in the hemoglobinometer tube.

Haemoglobin estimation in birds:

- 10 ml of 0.4% ammonium hydroxide solution is mixed with 20µl of blood sample.
- And then add 0.36% ml of concentrated HCI and mix.
- The precipitates of nucleic acids will settle at the bottom or float at the top and precipitates do not interfere with the colour development.

Then density of the colour is calorimetrically determined at 410 mµ wavelength and values are compared with standard curve as in case of cyanmet Hb method.

Skill Set (VETY) 5: Determination of packed cell volume (pcv) or haematocrit value

The word 'Hematocrit' is derived from two Greek words, *Haima* meaning blood, and *Krinein* meaning to separate i.e., to separate blood.

PCV: It is defined as percentage of total volume occupied by packed erythrocytes when a known volume of whole blood is centrifuged at a constant temperature in a specific time. PCV can be estimated by two methods.

- Wintrobe hematocrit tube method.
- Microhematocrit method.

Material required:

Wintrobe tube, syringe with a long needle, and centrifuge machine.

Procedure:

- Take the blood sample in the syringe with long needle and insert the needle in hematocrit tube so that the Wintrobe tube gets filled to the top without any air bubbles.
- Then make the level of the blood sample up to mark 10 on right side of the Wintrobe tube where calibration is from bottom to top.
- Put the tube into the centrifuge machine and rotate it at the speed of 3000 rpm for 30 minutes.
- After centrifugation we see erythrocyte mass at the bottom called as PCV.
- A white to gray layer of leucocytes and thrombocytes (platelets) occurring immediately above the red cell mass called as buffy coat and then there is plasma.
- The level at which packed red cell is found is multiplied by 10 which will give the PCV per 100 ml of blood or PCV%

Precautions:

- Wintrobe tube must be clean and dry.
- There should not be any air bubble in the tube.
- Proper amount of anticoagulant should be used
- Centrifugation should be done at the constant speed.

Microhematocrit method:

This method gives more accurate results consumes less time and needs very small quantity of blood, but needs a special centrifuge machine which is costly.

Material required:

Microhematocrit centrifuge machine, capillary tube, plasticine or clay.

Procedure:

- Apply one end of 7 cm long and 1 mm bore sized capillary tube to the surface of blood, it rises into the capillary tube by capillary attraction and surface tension.
- When the capillary tube is 2/3 filled. Remove it and seal the end of capillary tube by means of clay or plasticine or by flame.
- Place the capillary tube in the groove of the microhematocrit centrifuge in such a way that sealed end is away from centre, then centrifuge it at the speed of 10,000 rpm for 5 minutes.
- Then take the reading at the scale of microhematocrit centrifuge machine.

Precautions

- Sealed end of capillary tube must be away from the centre.
- Sealing of one end of the capillary tube must be proper to avoid leakage.

Roughly relationship between PCV, Hb and total erythrocyte counts (TEC) is as follows--

- $\frac{PCV}{3}$ = Hb gm%
- $\frac{PCV}{6}$ = TEC in millions per cubic mm or mm3
- 1 mm of buffy coat roughly indicate 10,000 leucocytes per cum. Low PCV indicates anaemia and higher value of PCV indicate the polycythemia.

Normal range of PCV in different species of domestic animals:

Species	**PCV %**
Cow and buffalo	24-46
Horse	32-52
Sheep	24-50
Goat	19-38
Pig	32-50
Dog	37-55
Cat	24-45
Fowl	27-42

Skill Set (VETY) 6: Separation of blood plasma and serum

The blood tends to coagulate after it is withdrawn from the blood vessel. After removal of the clot, left-out fluid is known as serum. Plasma can be separated by centrifugation of the blood mixed with an anticoagulant.

Plasma - Fibrinogen = Serum

Materials required:

Fresh blood, Anticoagulant, Vials or tubes, Conical flask. Glass rod or bead, Centrifuge tube, Centrifugation machine, and Cryovials etc.

Procedure for separation of plasma:

- Immediately after draw the blood, transfer the blood into the vials or tubes containing anticoagulant.
- Be sure to draw the full volume to ensure the correct blood-to –anticoagulant ratio.
- Mix the blood and anticoagulant and centrifuge @ 3000 rpm for 30 minutes.
- This will give three layers: from top to bottom- plasma, Buffy coat (leucocytes) and erythrocytes.
- The supernatant (plasma) should be transferred carefully. Take care not to disrupt the cells layer or transfer any cells.

Procedure for separation of serum

- Draw the whole blood into syringe and transfer the blood into a tube containing no anticoagulant**.**
- Incubate in an upright position at room temperature for 30-45 min (no longer than 60 min) to allow the blood clotting and centrifuge it for 30 minutes at 3000 rpm.
- The supernatant (serum) should be transferred carefully. Take care not to disrupt the cells or transfer any cells.

Skill Set (VETY) 7: Determination of sperm concentration

The sperm concentration is determined.

- To fix up dilution rate of semen.
- To diagnose infertility problems for e.g. testicular hypoplasia, testicular degeneration.

Requirement:

Haemocytometer set, Semen sample, Sperm counting fluid (water soluble eosin -50 mg, sodium chloride - 4.0g, distilled water 100 ml and a drop of formalin), Microscope, Watch glass, Muslin cloth, and Filter paper.

Procedure:

- Mix the semen sample in collection tube thoroughly but gently so that a representative sample is obtained.

- Suck semen up to 0.5 mark in RBC diluting pipette.
- Clean the tip of pipette and draw sperm counting fluid in the pipette up to 101 mark above the bulb.
- Roll the pipette between palms for 2-3 min to ensure thorough mixing.
- Discard few drops of diluted semen and charge the counting chamber of haemocytometer.
- Wait for 2-3 min to allow the spermatozoa to settle down.
- Count the no. of spermatozoa in 5 medium squares under high power of microscope.

Calculations:

80 small squares have X no. of sperms

So, 1 small square contain = $\frac{\mathbf{X}}{80}$

So, 400 small square will have = $\frac{\mathbf{X}}{80} \times 400$

1 sq mm area having 1/10 mm depth (0.1cu mm volume) have no. of spermatozoa

$$= \frac{\mathbf{X}}{80} \times 400 \times 10$$

Therefore, 1 cu mm volume will have = $\frac{\mathbf{X}}{80} \times 400 \times 10$ or $50\ \mathbf{X}$

Since the dilution is 200 times, 1 cu mm undiluted semen will have

$$= \frac{\mathbf{X}}{80} \times 400 \times 10 \times 200$$

$$= 10000\ X \text{ / cu mm or } \mu l$$

Result: The number of spermatozoa present in semen sample is _____ million / µl or cu mm.

Skill Set (VETY) 8: Collection and preservation of blood, urine and faeces for diagnosis of the diseases

For microbiological investigations, strict sterile precautions must be observed meticulously while collecting and handling materials for isolation studies. After collection of suitable material, it must be carefully packaged, labelled, and transmitted to the laboratory by the fastest practicable method. Relevant shipping regulations must be obeyed. All samples must be accompanied by a written note indicating the origin of the material, the relevant history and the tests required.

A. Collection of Samples:

1. Blood:

Blood samples may be taken for haematology or culture and/or direct examination for bacteria, viruses, or parasites, in that case the blood is added to anti-coagulants such as heparin. They may also be taken for serology where a clotted sample is required. A blood sample is taken after cleaning the site by shaving (plucking) hair and swabbing with 70% ethyl alcohol. The site is allowed to dry and then

venepuncture is performed. In most large mammals, the jugular vein or a caudal vein is selected, but brachial veins and mammary veins are also used. In birds, a wing vein (brachial vein) is usually selected.

Whole blood samples are sometimes collected in transport media with added antibiotics to reduce bacterial growth, but used antibiotics should not interfere with the growth of the pathogens concerned. For samples with anti-coagulants and/or antibiotics, thorough mixing is necessary as soon as the sample has been taken. It may be also necessary to make a smear of fresh blood on a microscope slide. An alternative method is to transport a drop of dried blood on a filter paper disk that contains enough material for sensitive antibody assay systems.

2. Urine:

Samples can be obtained via normal voiding or by manual compression of the urinary bladder. A mid-stream sample is preferred. In small animals, urine is readily collected using cystocentesis while in large animals, catheterization is the preferred method. Collected urine should be placed immediately into a sterile test tube and culture as soon as possible. And if delayed by more than one hour then the urine should be refrigerated.

3. Faeces:

Freshly voided feces should be collected and sent with or without a transport medium. An alternative and sometimes preferable method is to take swabs from the rectum (or cloaca), taking care to swab the mucosal surface. Swabs may also be transported either dry or in a transport medium.

B. Transport of Samples:

Samples must be carefully packed, to avoid any possibility of leakage or cross-contamination. The fresh samples should be forwarded to the laboratory by the fastest direct route. If they can reach the laboratory within 24 hours they should be forwarded in a wide-mouthed vacuum flask with wet ice. Some samples should not be frozen. Screw-capped bottles should be used and should be additionally sealed with adhesive tape or paraffin wax. Samples in individually identified containers should be placed in larger strong, outer containers and packed with enough absorbent material to protect from damage.

Official shipping regulations must be consulted. It is advisable to contact the laboratory in advance in the case of unusual requests. It is essential to do so, where material is sent to a laboratory in another country. Many countries require a special import license to be obtained in advance for any biological material, especially for tissues that could contain animal pathogens. This should accompany the package and be attached in an envelope to the outside of the parcel.

C. Preservation of Specimens

Various preservatives are used for different specimens, e.g. phosphate buffered glycerine for tissues; EDTA, sodium citrate, heparin or OCG mixture for whole blood and transport media (TPB) for swabs. The preserved specimens are most frequently transported on ice in a thermos flask or other suitable containers.

Skill Set (VETY) 9: Preparation of blood, urine and faecal smears

Blood Smear:

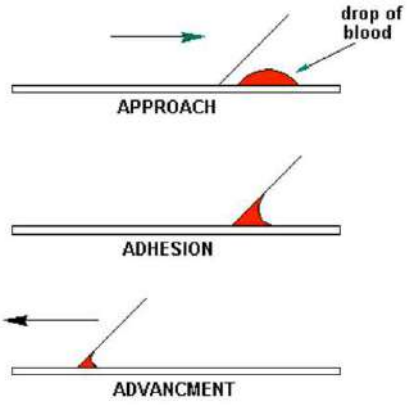
Blood is a body fluid that performs a variety of transport and regulatory functions. The heart pumps the blood around the body through the circulatory system. It consists of solid components and a liquid intercellular substance, blood plasma. This contains cellular solid particles formed in the bone marrow: the red blood cells (erythrocytes), the white blood cells (leukocytes), and the blood platelets (thrombocytes). These are responsible for specific functions within the body. The solid particles can be detected and identified with a light microscope.

A blood smear is a sample of blood that's spread on a glass slide which is treated with a special stain. In the past, all blood smears were examined under a microscope by laboratory professionals. Now automated digital systems may be used to help examine blood smears. A blood smear is used to help in diagnosing viral infections, bacterial infections and certain blood disorders such as leukaemia. Another procedure, thick smears, is used to detect malarial parasites in the blood.

Procedure:

It takes considerable practice to consistently make perfect blood smears. The handmade wedge or thin slide is the most commonly prepared blood film.

Three factors may be altered slightly to produce a perfect blood smear: speed, angle and drop size.



1. The faster the spreader slide is moved, the longer and thinner the film will be. The slower the slide is moved, the shorter and thicker the slide will be.
2. An angle greater than 30° makes the smear thicker; less than 30° the smear is thinner.
3. A small drop of blood may be insufficient to prepare a slide of sufficient length, too large a drop may cause the smear to extend beyond the length of the slide.
4. Then the smear is air dried, fixed, stained and examined under a microscope at a magnification of 1:40 or 1:100.

Urine smears:

In veterinary practice, urine sediment is commonly evaluated as part of a complete urinalysis performed as routine screening for urinary tract and systemic disease. Identification of formed elements in urine sediment (including cells, casts, and crystals) in wet-mount preparations requires training and expertise. Dry mounts are easy to prepare, and routine stains can be used for more in-depth patient-side in-clinic evaluation.

As part of a complete urinalysis, wet-mount samples are routinely reviewed unstained. At times, staining a wet-mounted urine preparation by using a urine sediment stain can improve visibility. However, staining can sometimes hinder wet-mount evaluation by introducing artefacts (stain precipitate, microbial overgrowth); cannot preserve cellular morphology (a common misconception); and, for those learning urine sediment, can make evaluation of wet mounts with artefacts more challenging than directly visualizing air-dried preparations stained with a routine in-clinic aqueous quick stain. Dry mounts stained with aqueous Romanowsky quick stain enable direct observation of neutrophil

and bacterial morphology without refractile artifacts and the Brownian motion (spontaneous movement of small particulates in fluid samples) seen on wet mounts. Timely analysis of wet-mount samples is paramount as formed elements in urine are labile and can degrade outside the body. Creating a dry-mount slide from the 10% urine sediment preparation is highly desirable because it enables further identification by using routine staining techniques that can serve both teaching and diagnostic purposes. The dry nature of the preparation allows for use of higher magnification oil objectives and creates a stable sample for analysis, including shipment to a reference laboratory if desired.

Procedure:

- Take 5 ml of urine, centrifuge for 5 minutes at 1500 RPM (revolutions per minute).
- Remove 4.5 ml of supernatant by gentle decanting or using a transfer pipette and re-suspend pellet in 0.5 ml of supernatant with gentle tapping or gentle aspiration with the pipette to mix.
- Use a pipette to transfer one drop of the reconstituted sediment to a microscope slide.
- Place a coverslip over the sample. When handling a coverslip, hold it at one corner.
- Evaluate wet-mount sediment at 10× low-power field, and red blood cells, white blood cells, bacteria, and crystals at 40 × high-power fields.
- A dry mount can be prepared by using 1 drop of the 10% urine sediment according to the blood push film technique.

Faecal Smear:

Faecal smear is a laboratory test of a stool sample. This test is done to check for bacteria and parasites. It is generally conducted in combination with a faecal flotation test, which is used to screen for intestinal parasite eggs. With a direct faecal smear, a thin film of faeces is examined under a microscope for evidence of Giardia, a protozoan parasite that can cause diarrhoea. A faecal smear can also be used to identify cellular abnormalities, bacterial or fungal organisms, and in some cases, parasite eggs.

Procedure:

- The key to a good faecal smear is to start with as fresh a sample as possible.
- A direct fecal smear is prepared by spreading a thin film of feces on a glass slide and adding a few drops of saline.
- The slide is then examined under a microscope for evidence of microscopic organisms.

A fecal smear can also be used to examine fecal cytology—the cells contained in the specimen. In this case, the slide is stained with special dyes to facilitate the visualization of cells, bacteria, and fungi. Clostridium and Campylobacter are two types of bacteria that often cause diarrhoea. Occasionally, fungal organisms may be identified. Cell abnormalities may help detect infection, haemorrhage, and in some cases, cancer.

Skill Set (VETY) 10: In-vitro culture of bacteria and methods of inoculation of bacteria in laboratory media

In a natural environment, a single kind of bacterium i.e. a bacterial species, usually occurs as only one component of a large and complex population containing many other species. To study the characteristics of one species, it must be separated from all others (species) i.e. it must be isolated in pure form. In order to obtain as well as maintain a pure culture, aseptic techniques should be adopted

which do not permit the introduction of contamination. Before attempting isolation, it is often helpful to use a selective method first, which can increase the relative proportion of the desired species in the population, so that it can more easily be isolated. Once obtained, a pure culture can be maintained or preserved in a culture collection center. Different species of bacteria growing on the same kind of medium may appear quite different, thus knowledge of the appearance or the cultural characteristic of a species is useful for the recognition of certain kinds of bacteria and may also serve as an aid to the identification of species.

Bacterial culture methods:

To be cultured successfully, bacteria require the provision of nutrients in the culture medium. There are many different formulations available to suit the differing nutritional needs of bacterial species. The type of medium you choose will depend on the purpose of the culture. Rich, nutrient or complete media can be helpful when trying to bulk up a pure culture and get the bacterial cells in good condition. Minimal media on the other hand will supply only the bare necessities for survival and can be useful in manipulating which pathways are turned on in the bacterium.

Media may also be classed as defined or undefined. As the name suggests, in a defined media, all the ingredients are known. Undefined media tend to contain complex mixtures of nutrients and chemical species in unknown proportions, such as yeast extract.

Whichever medium is chosen, this may be in liquid form as a broth culture, or agar may be added to set the media and allow bacterial cells to be grown on a solid surface.

Culture broth:

Culture in liquid media, also known as a broth culture, gives the bacteria present easy access to the available nutrients compared to static bacterial colonies. Gentle agitation to keep the bacteria dispersed through the medium during incubation can aid this access further. Liquid media will also dilute out waste products as they are formed, distributing them through the culture. Consequently, a greater mass of bacteria may be obtained for an equivalent volume of liquid as opposed to solid media.

Solid culture/ Nutrient agar:

Adding agar to liquid media enables it to be set in Petri dishes, as slopes or in plugs for example. Solid media is useful when you wish to select individual colonies from a mixed culture, for example when purifying a diagnostic sample. If you wish to enumerate the number of colonies forming units (cfu) within a given volume of liquid sample, plating and incubation on solid media also permits this.

Methods of Inoculation of Bacteria:

1. Streak plate method:

The most used technique for the isolation of pure culture on the solid medium to obtain single isolated colonies.

Procedure:

- Sterilize the inoculation loop, make it cool and pick up a small amount of bacterial culture aseptically near the flame.
- Open the lid of the petri plate near the flame and make a smear of culture at one side of the plate. At the same time make 3/4 parallel streaking lines at one side of the plate from the smear.
- Sterilize the inoculation loop; make it cool and make 3/4 parallel streaks across the first streaks.

- Repeat this step for another 2 /3 time across the previous streaking lines.
- Incubate the plate at 37^0C for 24 to 48 hours.

This procedure ensures the dilution of inoculum upon the medium to the extent that the inoculum is likely to contain only one viable organism. It is not possible to obtain a pure culture by using liquid medium.

2. Spot method:

It is not a commonly used method of inoculation but can be used when the organism in the inoculum is at low concentration.

Procedure:

- Sterilize the inoculation loop, make it cool and pick up a small quantity of inoculumaseptically.
- Open the lid of the Petri plate near the flame and rub the inoculum at a spot on the surface of the medium.
- Incubate the plate at 37^0C for 24 - 48 hours.

3. Shake culture method:

It is used to isolate a single colony of anaerobic bacteria using diluted inoculum.

Procedure:

- Add a loop full of bacterial broth culture to the nutrient broth tube and mix thoroughly.
- Melt the nutrient agar (sterilized) in a boiling water bath and allow it to cool to 46 - 48^0C.
- Add a loop full of diluted nutrient broth culture in melted nutrient agar and mix thoroughly to disperse uniformly in the medium. Allow the medium (culture) to become solid.
- Incubate the tube at 37^0C for 24-48 hours.
- After incubation, first heat the tube at the sides and then at the bottom in the direct place. The butt of agar will come out of the tube with a force.
- Cut out the colonies from the agar with the help of a knife and examine the colonies for cultural and morphological characters.

4. Pour plate method:

This method is most commonly used to demonstrate the viable count of bacteria.

Procedure:

- Melt 15ml of sterile nutrient agar in a boiling water bath and allow to cool at 46 - 48^0C.
- Add a loop full of broth culture in ~ 10ml sterile nutrient broth and mix it well.
- Add one loop full of mix culture broth to nutrient agar and mix well.
- Pour whole content (nutrient agar) to a sterile petri plate aseptically and allow becomingsolid.
- Incubate the plate at 37^0C for 24 - 48 hours.

5. Stroke culture method

It is used to inoculate the slant for biochemical tests or to store (maintain) the bacterial cultures.

Procedure:

- Sterilize the inoculation loop, make it cool, and pick up a small amount of inoculum aseptically near the flame.
- Insert the loop near the bottom of the slant and draw it gently over the surface of the mediumin a serpentine /zig-zag manner.
- Incubate the slant at 37^0C for 24-48 hours.

6. Stab method:

It is generally used to inoculate SIM medium or gelatin for liquefaction.

Procedure:

- Sterilize inoculation needle (loop is not used), make it cool and pick up a small quantity of bacterial culture at its tip aseptically near the flame.
- Introduce the needle perpendicularly into the medium without touching the side or bottom of the tube. Withdraw the needle through the same path without breaking the medium.
- Incubate the tube at 37^0C for 24-48 hours.

7. Inoculation of liquid medium:

- Sterilize the inoculation loop, make it cool and pick up a small amount of bacterial culture aseptically near the flame.
- Insert the loop inside the tube and gently rub the loop at the side of the broth to dislodge the inoculum into the medium. All aggregates should be broken down.
- Mix the contents uniformly in the medium by gentle tapping the tube on the palm of hand.
- Incubate the tube at 37^0C in an incubator (with or without shaker) for 24-48 hours.

Skill Set (VETY) 11: Histopathological techniques- processing of tissue for paraffin embedding technique, section cutting, staining and identification of microscopic lesions

Histopathology is the microscopical study of tissues for pathological alterations. This involves collection of morbid tissues from biopsy or necropsy, fixation, preparation of sections, staining and microscopical examination.

Steps in processing of tissue by paraffin embedding technique:

- Collection of tissue
- Fixation
- Dehydration
- Clearing
- Impregnation/ infiltration
- Embedding / block making
- Section cutting/ Sectioning
- Staining and mounting in slide

Collection of materials:

Thin pieces of 3 to 5 mm thickness are collected from tissues showing gross morbid changes along with normal tissue.

Preservation/Fixation of tissues: Keeping the tissues in a fixative for 24-48 hours at room temperature serves to

- harden the tissues by coagulating the cell protein,
- prevents autolysis,
- preserves the structure of the tissue,
- prevents shrinkage.

The fluids used for fixation is called fixatives. The volume of the fixative added is 10 times the volume of the tissues. Points to keep in mind while fixing tissues:

1. Tissue should be collected and placed in fixative as soon as possible
2. Size of tissue should not be more than 5mm thick (approx. 2mm)
3. Ratio of tissue and fixatives should be 1:10
4. If the tissues are fixed for too long there will be shrinkage of the tissue, and if fixed for short period reversal of fixation.
5. Optimal time 12-24hrs

Common fixatives:

1.	10% Neutral buffered formalin (pH 7.0)	
	Formalin (37-40%)	100ml
	Distilled water	900ml
	Sodium dihydrogen phosphate monohydrate (NaH_2PO_4)	4 g
	Disodium hydrogen phosphate anhydrous (Na_2HPO_4)	6.5 g
2.	**Formal Saline**	
	Formalin (37-40%)	100 ml
	Sodium chloride	9g
	Tap/distilled water	900 ml
3.	**10% formalin**	
	Formalin (37-40%)	100 ml
	Tap/distilled water	900 ml
4.	**Formalin-ammonium Bromide solution**	
	Formalin (37-40%)	15ml
	Ammonium Bromide	2g
	Tap/distilled water	85ml

Step I: Treat sections in 0.3 to 0.6% iodine in 70% alcohol for 5 to 10 minutes and rinse in water

Step II: Decolorize in 5% sodium thiosulphate for 1 to 5 minutes and wash in running water before proceeding with haematoxylin staining.

Heidenhan's "SUSA" Fluid	
Mercuric chloride	4.5 g
Sodium Chloride	0.5 g
40% formaldehyde	20 ml
Glacial acetic acid	4 ml
Trichloro acetic acid	2 ml
Distilled water	80 ml

This is similar to Zenker's but does not give the mercury precipitate. Fixation 12 hours followed by washing in 95% ethanol.

Bouin's fluid	
Saturated aqueous picric acid (about 1.2%)	75 ml
40% formaldehyde	20 ml
Glacial acetic acid	5 ml

Packaging/ Dispatch of specimen:

The value of laboratory findings is dependent on proper selection/preservation and dispatch of the material.

- It is highly desirable that material should be collected immediately after the death of the animal in fixatives, material from bodies in which decomposition has occurred is usually unsuitable for laboratory examination.
- All materials should be dispatched in properly sealed, leakproof, wide-mouth containers immediately after collection to the laboratory, through a messenger or air transport or speed post so that it is received by the concerned laboratory within 2-3 days.
- All bottles/containers should be properly labeled and contained in a packaging material containing a sufficient quantity of absorbent material like sawdust, cotton wool, or any other absorbent. All parcels should be conspicuously marked "FRAGILE, HANDLE WITH CARE" and bear "Pathological specimen".
- The specimen should accompany the information regarding species, breed, age, sex, date and time of death and collection of material, type of examination desired, nature of specimen sent, disease suspected, and necropsy finding in a separate plastic bag.
- Specimen packed for rabies, glander, anthrax should be marked "SUSPECTED FOR……."

Post fixation treatment:

Decalcification: it is the process by which heavily concentrated deposits of calcium are removed from the tissues. Calcified tissues viz. bones or calcareous plates cannot be sectioned by routine methods and need to be calcified. The process is meant for softening hard tissues like bone and teeth to facilitate sectioning in ordinary microtomes. Decalcification is done after fixing the tissues.

Commonly used decalcifying solutions:

<table>
<tr><td rowspan="4">1.</td><td colspan="3">5% Nitric acid solution aqueous</td></tr>
<tr><td colspan="2">Nitric acid (conc.)</td><td>5ml</td></tr>
<tr><td colspan="2">Distilled water</td><td>95ml</td></tr>
<tr><td colspan="3">After decalcification (several days) wash in running water for 30 mins and then neutralize in 10% formalin with excess of calcium or magnesium carbonate for at least 5 hrs. Wash again in running water overnight.</td></tr>
<tr><td rowspan="4">2.</td><td colspan="3">5% Nitric acid solution alcoholic</td></tr>
<tr><td colspan="2">Alcohol 80%</td><td>95ml</td></tr>
<tr><td colspan="2">Nitric acid (conc.)</td><td>5ml</td></tr>
<tr><td colspan="3">After decalcification treat with 4% aqueous sodium sulphate for 3 hrs and then wash in running water for at least 2 hrs.</td></tr>
<tr><td rowspan="5">3.</td><td colspan="3">Formic acid- sodium citrate method</td></tr>
<tr><td rowspan="2">Solution A</td><td>Sodium citrate</td><td>50gm</td></tr>
<tr><td>Distilled water</td><td>250ml</td></tr>
<tr><td rowspan="2">Solution B</td><td>Formic acid 90%</td><td>125ml</td></tr>
<tr><td>Distilled water</td><td>125ml</td></tr>
<tr><td colspan="4">Working solution: equal quantities of solution A and B</td></tr>
</table>

Check for completion of decalcification:

1. Take 5ml of used decalcifying solution in a clean test tube.

2. Add 1ml of 5% aqueous sodium or ammonium oxalate. Allow to stand for 5 mins.

Result: Formation of precipitate: incomplete decalcification.

No precipitate: complete decalcification.

Skill Set (VETY) 12: Selection of male and female animals for breeding

Selection is a crucial process in animal breeding aimed at choosing superior parents for the next generation. Selecting the right male and female animals for breeding is crucial for achieving the desired breeding goals and producing offspring with desirable traits. Here's a detailed explanation of the selection process:

Define Breeding Objectives:

- Clearly define the breeding objectives, including the traits and characteristics you want to improve or maintain in the offspring.
- Consider factors such as productivity, conformation, temperament, health, and genetic diversity when setting breeding goals.

Evaluate Pedigree and Genetics:

- Examine the pedigree of potential breeding animals to understand their genetic background and ancestry.
- Look for individuals with a strong pedigree, preferably with ancestors that have demonstrated desirable traits or performance records.
- Consider the genetic diversity within the pedigree to avoid inbreeding and maintain genetic health in the offspring.

Assess Phenotype and Conformation:

- Evaluate the physical characteristics and conformation of potential breeding animals, considering traits such as body size, structure, coat colour, and overall appearance.
- Look for animals that meet the breed standards or have desirable phenotypic traits relevant to your breeding objectives.
- Consider the functional traits that contribute to the animal's performance and suitability for its intended purpose, whether it's meat production, milk production, or companionship.

Performance Testing:

- Conduct performance testing to assess the individual's ability to meet breeding objectives.
- For livestock, performance testing may include measuring traits such as growth rate, milk yield, feed efficiency, reproductive efficiency, and disease resistance.
- Use performance data to identify animals with superior genetic merit and breeding potential.

Health Screening:

- Screen potential breeding animals for genetic disorders, hereditary diseases, and other health concerns prevalent in the breed.
- Conduct genetic testing and health examinations to identify carriers of genetic mutations or conditions that could be passed on to the offspring.
- Select animals with a clean bill of health and low risk of transmitting genetic disorders to future generations.

Temperament and Behaviour:

- Assess the temperament and behaviour of potential breeding animals, especially for companion animals.
- Look for individuals with desirable temperamental traits, such as friendliness, trainability, sociability, and calmness.
- Avoid breeding animals with aggressive tendencies, fearfulness, or behavioural issues that could be passed on to the offspring.

Compatibility and Genetic Diversity:

- Consider the compatibility of potential mating pairs to ensure genetic complimentarily and avoid negative genetic interactions.
- Balance the need for genetic diversity with the desire to maintain desirable traits within the population.

- Avoid close inbreeding and aim for an optimal level of genetic diversity to maintain the health and vigor of the offspring.

Long-Term Breeding Goals:

- Consider the long-term implications of breeding decisions on the overall genetic improvement and sustainability of the population.
- Plan breeding programs with a multi-generational perspective, focusing on gradual progress and continuous improvement over time.
- Monitor the outcomes of breeding decisions and adjust selection criteria as needed to achieve the desired breeding objectives.

By carefully selecting male and female animals for breeding based on these considerations, breeders can maximize the likelihood of producing offspring with desirable traits, improve the overall quality of the population, and contribute to the long-term success of their breeding program.

Breeding management of pet animals

Breeding management of pet animals requires careful planning and consideration to ensure the health, welfare, and quality of the offspring. Here's a detailed explanation of breeding management practices for pet animals:

Skill Set (VETY) 13: Quality evaluation of feeds and fodders

Feed quality evaluation:

Feed quality evaluation is important because ingredients that belong to the same class contain different nutrients; for example, maize provides more energy than wheat while soybeans contain more proteins than sesame and sunflower seeds. The same ingredient varies in its quality from one supplier to the other, between years and between seasons within a year.

Adulterants, contaminants, and toxins should also be taken into account as their presence in feed ingredients renders them inferior and harmful, adversely affecting the overall quality of the finished feed. To identify and avoid such low-quality feed ingredients, feed quality evaluation is of paramount importance. Feeds and feed ingredients can be evaluated for quality by physical, and sensory evaluation methods in the field as well as in the laboratory adopting chemical methods

Physical evaluation:

The physical inspection and sensory evaluation (colour, size, homogeneity, smell, taste, touch, sound) of feed mostly provides preliminary information on the quality of the material and therefore mostly useful to identify gross adulteration. One must be highly trained to identify the changes like the raw materials/ feeds.

Feed microscopy:

Determining and evaluating the quality of feed ingredients and finished feeds and the extent of adulteration and contamination with the help of a microscope is called feed microscopy.

This is an improvement over direct visual examination. Here the feedstuffs are examined under a wide-field microscope.

Feed microscopy involves the identification and evaluation of feed ingredients and foreign materials alone or in a mixture either via surface ingredients or cellular characteristics. If ingredients and contaminants are separated and their proportions are measured, then feed microscopy can be used for quantitative evaluation of feed ingredients. Therefore, feed microscopy can satisfactorily tell the purity of feed ingredients, and the acceptance and rejection decisions are made just after comparison with standard photomicrograph catalog. Adulterants like husk, hulls, stones, foreign bodies, and substitution with cheaper materials can be easily detected by microscopic examinations. The presence of hair/ leather meal in fish/ meat meal, castor seed meal in sesame/ sunflower meal and similar cheaper substitutes can be detected.

Common adulterants in feeds

Adulteration is defined as the admixture of a pure substance with some cheaper and low-quality substance. It is done intentionally usually to make money. In costly feed ingredients like oil seed cakes, adulteration is done by spraying urea to raise their protein content. However, sometimes brans are also added. Besides urea, oilseed cakes are adulterated with husk, non-edible oilseed cakes etc. The common contaminant or adulterant is husk or sand. Winnowing is the best method to detect husk in the feedstuffs. Sieving can be done to differentiate contaminants based on particle size.

Feed ingredients	**Common adulterants**
Groundnut cake	Groundnut husk, urea, non-edible oil cakes
Mustard cake	*Argemone mexicana* seeds, fibrous feed ingredients, urea
Soybean meal	Urea, raw soybean, hulls
De-oiled rice bran, wheat bran	Ground rice husk saw dust
Mineral mixture	Common salt, marble powder, sand, limestone
Molasses	Water
Maize	Cobs, cob dust, sand
Rice kani	Marble, grit

Chemical evaluation:

Chemically, feed is made up of water and dry matter containing organic and inorganic compounds. The organic part is made of mainly carbohydrates, proteins, vitamins, fats and oils. The inorganic part is made of mineral elements, also known as ash. Feed or feed ingredients can be analyzed for proximate principles to provide the values of each of these components.

The feed sample is dried and the loss in weight gives its water content. The dry matter is then combusted at about 550° C to oxidize the organic materials and leave the ash. The organic fraction consists of a variety of carbohydrates, fats, and proteins whereas the ash consists mainly of minerals. In the organic fraction, the carbohydrates (found in the NFE) and fats (EE) are the primary sources of energy in animals.

Proximate principles	Analysis processing	Constituents
Water (W)	Dry at 70–100°C	Water, volatile compounds
Ash (A)	Burn off OM at 500°C	Minerals
Crude protein (CP)	Total N analysis x 6.25	Protein, other NPN
Ether extract (EE)	Reflux with ether	Fats, oils, waxes, pigments, sterols
Nitrogen free extract (NFE)	100 – (W+A+CP+EE+CF)	Starch, pectin, organic acid
Crude fibre (CF)	Residue after boiling in alkali and acid	Hemi cellulose, cellulose, lignin

An analytical laboratory for precise estimation of nutrient contents and contaminant is of utmost importance. Low crude protein (CP) and high crude fibre (CF) of oil seed meals indicate adulteration with fibrous materials. The high CP alone is indicative of adulteration with urea and or some inferior quality oil seed meals like mahua, castor, or karanj cake. The amount of acid-insoluble ash is a good guide to the amount of sand or other dirt that may be present. It is also desirable to determine the free fatty acid content of oily materials as this will affect palatability due to the rancidity of oil.

The chemical methods include laboratory analysis of anti-nutritional factors like mycotoxins, insecticides, herbicides, fungicides, phytoestrogens, glucosinolates, saponins, tannins, ricin, sinapine, gossypol, lipoxygenase, trypsin inhibitor, etc.

Advanced Technique for Feed Evaluation:

Near-infrared reflectance spectroscopy (NIRS) is one of the latest techniques by which feed ingredients can be evaluated with the most minimal preparation of the sample. NIRS provides the capability to rapidly measuring crude protein, fibre, fat, total and digestible amino acids, calcium, total and available phosphorus and also the energy value (ME) of individual ingredients. In general, NIR analysis has high accuracy in measuring crude protein and fiber fractions compared to wet chemistry, but is less accurate in measuring feed mineral content. The main limitation in the use of NIRS technology is the cost involved in the setting up of the system. Also, it requires calibration which in turn requires a large number of samples sets.

Skill Set (VETY) 14: Preparation of ointment and lotion

1. Preparation of simple ointment:

Materials Requirements:

Ingredients, Dispensing scale , weight box, Enamel cups, fire tongs, Gas burner/Heater/Hot Plate, Horn spatula, gallipots, labels etc.

Composition for 100 grams:

- Wool fat 5g
- Hard paraffin 10g
- White/yellow soft Paraffin 85 G

Procedure:

- Weigh the required amount of wool fat on a piece of paper on the dispensing scale and transfer it into an enamel cup.
- Weigh the required amount of hard paraffin and white/yellow soft paraffin and put it into the enamel cup containing the wool fat.
- Place the enamel cup over a burner/hot plate for melting. Stir with the help of a horn spatula and cool it.
- Dispense in a gallipot with proper labelling.

Action: Emollient.

Uses:

- Local application to cracked teats and dry and rough skin.
- Used as a base for the preparation of other ointments.

2. Preparation of paraffin ointment:

Materials Requirements:

Ingredients, Dispensing scale, weight box, Enamel cups, fire tongs, Gas burner/Heater/Hot Plate, Horn spatula, gallipots, labels etc.

Composition for 100 grams:

- White bee wax 2 g
- Hard paraffin 8 g
- White/yellow Paraffin 90 g

Procedure:

- Weigh the required amount of white bee wax on a piece of paper on the dispensing scale and transfer it into an enamel cup.
- Weigh the required amount of hard paraffin and white/yellow soft paraffin and put it into the enamel cup containing the wool fat.
- Place the enamel cup over a burner/hot plate for melting. Stir with the help of a horn spatula and cool it.
- Dispense in a gallipot with proper labelling.

Action: Emollient.

Uses:

- Local application to cracked teats and dry and rough skin.
- Used as a base for the preparation of other ointments.

3. Preparation of non-staining ointment of iodine:

Materials Requirements:

- Ingredients
- Dispensing scale and weight box
- Horn spatula, gallipots, labels, etc.

Composition for 100 grams:

- Iodine 5g
- Arachis oil 15 ml
- White/yellow soft Paraffin to make 100g

Procedure:

- Weigh the required amount of iodine and dissolve by shaking it with Arachis oil at 50°C with occasional stirring until brown colour disappears
- Mix the iodine containing arachis oil with sufficient yellow soft previously heated at 40°C to produce an ointment containing 5 % w/w of iodine.
- Dispense in a gallipot with proper labelling.

Action and Uses: Iodine is antiseptic and counterirritant. It is used as a counter-irritant ointment.

4. Preparation of non-staining ointment of iodine with methyl salicylate:

Materials Requirements:

Ingredients, Dispensing scale, weight box, Horn spatula, gallipots, labels, etc.

Composition for 100 grams:

- Methyl salicylate 5 ml
- Non-staining Iodine ointment to make 100 g

Procedure:

- Melt the non-staining ointment of iodine at a low temperature and add the required amount of methyl salicylate with continuous stirring until cold.
- Dispense in a gallipot with proper labelling.

Action: Methyl salicylate is rubefacient, counterirritant with some analgesic action.

Uses: Rubefacient ointment.

5. Preparation of turpentine ointment:

Materials Requirements:

- Turpentine Oil: 2.5 ml
- Vaseline or white/soft paraffin: 25 g

Procedure:

- Weigh the required amount of Vaseline or white/soft paraffin on a piece of paper and place it at one corner of an ointment slab.
- Measure and transfer 2.5 ml of turpentine oil in a small glass beaker using a clean pipette.
- Mix the ingredients gradually by taking small quantities of each at a time using ointment spatula.
- Repeat the procedure until whole of the Vaseline is properly mixed with the turpentine oil.
- Dispense in a galipot with proper labelling.

Use: Fly repellent.

6. Preparation of boric acid ointment:

Materials Requirements:

Ingredients, Dispensing scale, weight box, Enamel cups, Fire tongs, Gas burner/Heater/Hot Plate, Horn spatula, gallipots, labels etc.

Composition for 100 grams:

- Boric Acid 1 g
- Paraffin Ointment 99 g
- Mft. *Unguentum*

Procedures:

- Weigh the required amount of boric acid and place it on the centre of an ointment slab.
- Weigh paraffin ointment and place on the corner of the same ointment slab where boric acid is placed.
- With the help of a stainless-steel spatula, take a small amount of the paraffin ointment and mix with the boric acid. Repeat the procedure till all the ointment is mixed thoroughly and homogenously with boric acid.
- Transfer it into a gallipot and label it properly.

Actions and Uses: Boric acid is a weak non-irritant antiseptic that inhibits the growth of certain bacteria and fungi. It is used for application to wounds, ulcers, and inflamed mucous membranes asanm emollient antiseptic. It is also used in eczema in dogs.

Skill Set (VETY) 15: Detection of common food adulterants in animal sourced food

Chromatographic techniques:

The chromatographic methods used for isolating, separating, quantifying and confirming the presence of dangerous residues in samples would be gas chromatography, Thin Layer Chromatography, high performance liquid chromatography (HPLC).

A number of analytical techniques such as colorimetric method, Thin Layer Chromatography, High Performance-Thin Layer Chromatography used for mycotoxins, Gas Liquid Chromatography, Gas Chromatography-Mass Spectrometry, High Performance Liquid Chromatography (HPLC), Liquid Chromatography-Mass Spectrometry-Mass Photometry, etc., are established for detection and quantification of pesticide residues in animal tissues. However, colorimetric and Thin Layer Chromatography methods are limited only to qualitative determination due to their low sensitivity. Gas Liquid Chromatography or Gas Chromatography-Mass Spectrometry though normally used for the determination of non-volatile compounds (organochlorine and organophosphorus pesticides), but also effectively utilized for the determination of thermo- labile compounds such as synthetic pyrethroid and N-methyl carbamate pesticides.

Immunological techniques:

Antigen and antibody reactions have been used for many years to detect a wide variety of food constituents including substances responsible for adulterations and contaminations. The interaction antigen-antibody is very specific and useful for the detection of residues of chemical and veterinary drugs in animal foods. The most usual technique consists in the enzyme-linked-immunosorbent assay

(ELISA) and the detection system is usually based on enzyme-labeled reagents.

Radioimmunoassay (RIA):

It implies the measure of radioactivity of immunological complex using a counter. Other possibilities include the measure of chemi-luminescence with a luminometer when achemi-luminiscent compound is bound to the antibody or fluorescence with a fluorimeter when a fluorescent compound is used. They allow enhanced detectability about conventional colorimetry.

Biosensors:

Another recent approach to screening animal products for veterinary drugs, ensuring the quality and safety of meat and dairy products consists in the development of biosensors. These instruments comprise two elements: a biological recognition element, usually an antibody, and a signal transduction element which is in close contact and connected to data acquisition and processing systems.

Biosensors are getting expanded applications in food analysis. In general, there are several elements. The target analyte contacts the biological receptor (antibody) and the biochemical signal is converted by a transducer into an electronic signal. Then, these signals are processed by a microprocessor that gives the final result. Biosensors are designed to operate in real-time and be able for the simultaneous detection of single or multiple veterinary drug residues in a sample at a time.

Skill Set (VETY) 16: Determination of bacteriological quality of animal sourced food

There are mainly three methods for the bacteriological examination of milk and milk products. They are:

1. Standard Plate Count or Total Viable Count.
2. Coliform Count.
3. Faecal Streptococcal Count.

1. Standard Plate Count or Total Viable Count:

Two techniques for standard plate count or total viable count.

A). Pour Plate technique. B). Spread Plate technique.

Apparatus required:

Sample, Sterile Petri dishes, Sterile test tubes, Sterile pipettes, Sterile normal saline solution, Test tube stand, Tryptone glucose yeast extract agar/nutrient agar.

Preparation of dilution:

- Take 10 sterile test tubes and arrange them in the test tube stand**.**
- With the help of a sterile pipette transfer 9 ml sterile NSS in each of the test tubes.
- Add 1 ml of milk sample to the test tubes and mix thoroughly and from the first tube pipette out 1 ml and pour into the 2nd tube and mix thoroughly.

- Repeat the same process to the 3rd, 4th, 5th, and so on till the last tube, and from the last tube discard 1 ml.
- Thus, the dilution in the different test tubes is and so on respectively.

Pour Plate Technique:

- Take 6 Petri dishes for each dilution i.e. 2 plates each for the mesophilic count, thermophilic count, and psychrophilic count.
- From the desired dilution take 1 ml inoculum in each petri dish/plate.
- Pour 15 – 20 ml of TGYEA medium, which is kept at 45°C in melting condition in all the petri dishes and rotate the petri dish so that the inoculum mixes with the medium.
- Leave the petri dishes on the table for solidification.
- Then for psychrophilic count incubate 2 plates at 7°C for 7 days, mesophilic count incubates 2 plates at 37°C for 24 hours and for thermophilic count incubate 2 plates at 45°C for 24 hours.
- The plates showing 30 – 300 colonies are selected for counting. If the number of colonies in the plate is uncountable then it is not for counting.
- Total number of bacteria in milk = Average no. of the plates x dilution factor per ml.

Spread Plate Technique:

Apparatus required:

Sample, Sterile petri dishes, Sterile test tubes, Sterile pipettes, Sterile normal saline solution, Test tube stand, Tryptone glucose yeast extract agar/nutrient agar, Sterile 'L' shaped glass rod.

Procedure:

- Take the TGYEA plate and put 0.1 ml of the inoculum from the desired dilution with the help of a pipette.
- Spread the inoculum on the medium with the help of an 'L' shaped glass rod.
- The remaining process is the same as above.
- Total number of bacteria present in milk = Average no. of count of the plates x 10 x dilution factor.

2. Coliform count (Spread Plate Technique):

Apparatus required:

Sample, Sterile petri dishes, Sterile test tubes, Sterile pipettes,Sterile normal saline solution,Test tube stand,Tryptone glucose yeast extract agar/nutrient agar,Sterile 'L' shaped glass rod,Mac Conkey

Procedure:

- Pour 0.1 ml inoculum from the desired dilution with the help of a pipette on Mac Conkey agar plates.
- Then spread the inoculum with the help of sterile 'L' shaped glass rod and allow to solidify.
- Incubate the plates at 37°C for 24 hours.
- After incubation select lactase fermenter colonies i.e. pink colony.

- Then calculate the total number of bacteria in milk = Average no. of plate x 10 x dilution factor per ml.

3. Faecal Streptococcal Count:

Apparatus required:

Sample, Sterile petri dishes, Sterile test tubes,Sterile pipettes,Sterile normal saline solution,Test tube stand,Tryptone glucose yeast extract agar/nutrient agar,Sterile 'L' shaped glass rod,Media – Slanetz and Bartley agar

Procedure:

- Take Slanetz and Bartley agar plate and pure 0.1 ml inoculum from the desire dilution with the help of a sterile pipette.
- Spread the inoculum with the help of sterile 'L' shaped glass rod and allow to solidify.
- Then inoculate the plates at 37°C for 48 – 72 hours.
- Select pinpoint pink colonies surrounded by white zones for count.
- Then calculate the total number of bacteria in milk as follow

  = No. of colonies x 10 x dilution factor per ml.

Skill Set (VETY) 17: Preparation and examination of blood smear for diagnosis of parasitic diseases

Blood is examined for the detection of haemoparasites and microfilariae of filarial nematodes. For animals like cows, sheep, goats, horses, and camels venipuncture is done and blood is collected from the jugular with the help of a needle and syringe. In dogs and cats blood is collected from the saphenous vein. In pigs, blood is collected from the ear vein or anterior vena cava. In the case of birds, blood is collected from the wing vein or puncturing the comb and wattle. The collected blood is then put in properly labelled Ethylene Diamine Tetra Acetic Acid (EDTA) vials.

Blood smear preparation:

Wet Smear/Direct Smear:

This is a simple and rapid method for the detection of live trypanosomes and microfilariae.

Procedure:

- Place one drop of fresh venous blood on a clean glass slide and put a coverslip over it.
- Examine under low power (10X) magnification and look for the undulating movements of microfilariae and trypanosomes.

Thin blood smear:

Thin blood films are used for the detection of blood parasites.

Procedure:

- Put a drop of blood on the slide. Bring a clean spreader slide, held at a 45° angle, toward the drop of blood on the slide.
- Wait until the blood spreads along the entire width of the spreader slide by capillary action.
- While holding the spreader slide at the same angle, push it forward rapidly and smoothly.
- Wait until the thin films are completely dry and fix it with methanol before staining.

Thick Blood films:

Procedure:

- Using the corner of a clean slide, spread the drop of blood in a circle the size of 1-2 cm diameter. Do not make the smear too thick or it will fall off the slide.
- Wait until the thick films are completely dry before staining. The thick film should not be fixed.

Staining of blood smears for demonstration of haemoparasites:

Giemsa Stain Composition

- Giemsa stain 0.75 g
- Glycerol 25 ml
- Methanol 75 ml

For preparing Giemsa stain is placed in a mortar and glycerol is added to make a paste by mixing with pestle. Methanol is then added and stirred for mixing. It is poured in a dark bottle and incubated at 37°C for 24 hrs.

Giemsa's staining procedure for thin blood smear:

1. Fix blood slides in methanol for 5 minutes.
2. Air dry.
3. Dilute Giemsa Stain 1:10 with deionized water. Colour can be varied by diluting in the buffer.
4. Stain blood film for 15-45 minutes by immersing it in Giemsa stain or by dropping stain in film placed in a staining rack.
5. Rinse in deionized water.
6. Air dry and examine under oil immersion.
7. Mounting of the slide is done using mounting medium such as Canada balsam or DPX

Giemsa's staining procedure for thick blood smear:

Thick blood smear should not be fixed but should be dehaemoglobinized in water and then stained with Giemsa stain as mentioned above.

Leishman's Stain Composition:

- Leishman stain 150 mg
- Methanol 100 ml

The stain and methanol are added to a dark coloured bottle and shaken from time to time.

Procedure:

- Fully cover the smears with Leishman's Stain solution for 2 minutes.
- Add twice the amount of distilled water and mix by swirling. Incubate for at least 10 minutes.
- Rinse thoroughly with distilled water.
- Air dry and examine under oil immersion.
- For fixing slides Canada balsam or DPX is used.

Modified knott's method:

This technique is used for the detection and identification of blood-borne microfilariae. It was developed for the detection of *Dirofilaria immitis* microfilariae in canine blood. *Dirofilaria immitis* microfilariae can persist in a positive animal that has been treated for up to six months after treatment.

Procedure:

- Add 1 ml of freshly-drawn blood to 9 ml of 2% formalin (aqueous) in a centrifuge tube.
- Mix well to lyse red blood cells.
- Centrifuge for 5 minutes at 1500 rpm.
- Pour off supernatant fluid and keep the sediment in the centrifuge tube.
- Add a drop of 0.1% aqueous methylene blue. (Adjust the amount to suit yourself; it stains the microfilariae blue and makes them much easier to see.) Then stir or mix up the sediment in the bottom of the tube.
- Mix again and place a drop of the stained mixture on a microscope slide and add a cover slip.
- Examine slide under a microscope

The Knott's Technique is not recommended as a stand-alone diagnostic test for *Dirofilaria immitis* because infections may consist of male worms that do not produce microfilariae, or immature female worms that are not yet producing microfilariae.

Skill Set (VETY) 18: Preparation and examination of faecal sample

Faecal examination techniques:

The eggs/larvae of helminth parasites and the oocyst/cyst/trophozoites of protozoan parasites are excreted along with the feces. Fecal examination is done to detect or diagnose the parasitic eggs of various helminths and the oocyst of protozoan parasites.

Collection of fecal samples:

Fresh fecal samples should be collected preferably from the rectum of animals wearing a clean glove to avoid contamination. In the case of small animals like sheep goat and pisg moistened index finger is inserted in the rectum. For dogs and cats little finger is used for the collection of feces from the anus. Fresh fecal samples may also be collected from the floor of the animal house with minimal

contamination. The faecal material collected should be free from contamination such as soil, stones, and bedding materials. The faecal sample may be collected in fresh and clean polythene bags or plastic containers having proper sealing lids. Sample should be labeled with animal identification, species, breed, location, and date. Sometimes there may be a requirement for pooling of the faecal samples from the animal houses.

Preservation of faecal samples:

Preservation of the faecal samples is done to minimize the further development of parasitic eggs or oocyst or as embryonation is rapid. If immediate examination of the fecal samples cannot be performed collected faecal samples are refrigerated or preserved in 5-10% formalin without the further development of eggs.

Gross or Macroscopic Examination of the Faecal Material:

Consistency: The consistencies of the collected faecal material indicate whether the animal is having soft or watery stool indicating diarrhoea or very hard feces indicating constipation.

Colour: Unusual fecal colour such as light grey faeces indicate excessive fat in the feces or presence of excessive bile or blood.

Gross examination for the presence of adult parasites: Adult nematode parasites, segments of tapeworm, or larval stages of insects such as bots can be grossly seen with the naked eye.

Presence of blood: Blood in the faeces is caused due to the severe parasitic infection. Blood may appear black or tar-like. Fresh blood indicates haemorrhage in the rectum and blackened indicates haemorrhage in the stomach or intestine.

Mucus: The presence of mucus may indicate the presence of parasitic infection.

Qualitative examination of faecal sample:

Animals discharged the majority of the helminth eggs and the oocyst of protozoa in their feces. Fecal examination is done to diagnose helminthic as well as protozoan infection. Critical examination of the fecal sample in a parasitology laboratory should be done to detect and diagnose the presence of eggs or ova. Qualitative examination methods for the detection of eggs or ova are of the following types:

1. Direct Smear Method:

2. Concentration Methods:

a) Sedimentation

i) By Gravitation

ii) By Centrifugation

b) Floatation

i) By Levitation

ii) By Centrifugation

Direct Examination of Faeces:

A small quantity of faecal sample is placed on a glass slide and mixed well with 3-4 drops of water or physiological normal saline. The faecal sample is properly mixed with a needle/stick evenly spread over the slide and covered with a coverslip. Examination is done in the microscope at low power (10X) for helminth eggs and high power (40X) for oocyst. This method is easy, simple and quick for the detection of heavy infection. This method may not detect light infection. Eggs and oocyst have to be

searched out from the fecal debris. Eggs and oocysts may not be found in this method in which case concentration methods can be used for the detection of eggs and ova.

Concentration Methods:

Principle: The principle of concentration methods is to concentrate all the eggs in a given amount of faecal samples and then examined under the microscope.

Requirements: Microscope, pestle and mortar, glass slide, cover slip, strainer, floatation tube, centrifuge machine, centrifuge tube, floatation solution (saturated salt solution, sugar solution or zinc sulphate 33%), wash bottle, glass rod, etc.

Sedimentation Technique

Sedimentation by Gravitation

This method is essential for the detection of heavy eggs (trematode) having higher specific gravity. This method is time consuming but is good for detection of light infection. This method is not suitable for light eggs as they may be lost during washing and is not to be used for the detection of protozoan oocyst.

- A small quantity of faecal sample is taken in a sample tube or urine glass.
- If the faeces is of solid consistency mixed well with water in a pestle and mortar.
- The emulsified material is then strained through a strainer in the container and allowed to settle for 10 minutes.
- The supernatant fluid is then gently decanted or drained out.
- This process is repeated until the sediment is clearly washed.
- The sediment is then taken in a glass slide and then examined under low power (10X) microscope with or without cover glass.

Centrifugal Sedimentation Method:

- A small quantity of the faecal sample is pestled with water in a mortar ensuring proper emulsification.
- The emulsified material is then strained through a strainer to remove the coarse particles.
- The filtrate is then transferred in a centrifuge tube up to almost the brim of the tube.
- Centrifugation is done at 2,000 rpm for 2 minutes, ensuring that the tubes are properly balanced.
- The supernatant is then poured off.
- The process is repeated until the supernatant becomes clear.
- The sediment is then placed on a clean slide covered with a cover slip.
- Examine under low power (10X) microscope for the presence of eggs.

This method is suitable for the eggs of nematodes, cestodes and trematodes. Lights eggs are not lost. Eggs are to be searched out of the debris.

Floatation Technique:

Principle: The principle of the floatation method is that the parasitic eggs having lower specific gravity will float on the floatation fluid having higher specific gravity. Nematodes and cestodes eggs will float in a liquid having a specific gravity above 1.10 and trematode eggs will only float in a liquid having specific gravity of 1.35 which are not easily available.

Common floatation solutions

- Saturated Salt Solution (Specific gravity: 1.18-1.19)
- Saturated sugar solution (Specific gravity: 1.25)
- Magnesium sulphate (Specific gravity: 1.18)
- Zinc Sulphate 33% solution (Specific gravity: 1.18)

Floatation by Centrifugation:

- A small quantity of faecal sample is taken in a clean mortar.
- The faecal sample is then mixed with floatation solution and emulsification is done thoroughly with pestle and mortar.
- Strain to remove any faecal debris.
- Transfer the material in a centrifuge tube without completely filling up the tube.
- Centrifuge at 1000 rpm for 2mins.
- A few drops from the topmost layer is taken with a dropper or a wire loop and placed in a microslide.
- Cover it with a coverslip and examine under low power (10X) microscope.

This method is very quick and essential for light infection and for the detection of oocyst and cyst of protozoan infection.

Floatation by Levitation:

- A small quantity of faecal sample is mixed with water using pestle and mortar.
- Add few ml. of saturated salt solution or any other floatation solution and emulsify it.
- Fill the floatation tube with the emulsified material up to its brim without the content overflowing and a convex surface is formed.
- A slide is placed over it touching the floatation fluid.
- Allow it to stand for 20-30 minutes during which time all the eggs will rise to the surface of the solution. Adherence of eggs will take place due to capillary action.
- The slide is then examined under low power for presence of eggs.

This technique is good for the detection of light infection of nematode eggs without the presence of faecal debris. Distortion of the eggs may occur if kept for long duration of time.

Skill Set (VETY) 19: Quantitative faecal examination/egg counting technique

Mc Master Egg Counting Technique

- The McMaster technique is used for demonstrating and counting helminth eggs in faecal samples. It is the most widely employed method for this purpose.
- The McMaster technique uses a counting chamber which enables a known volume of faecal suspension (2 x 0.15 ml) to be examined microscopically.
- Thus, if a known weight of faeces and a known volume of flotation fluid are used to prepare the suspension, then the number of eggs per gram of faeces (EPG) can be calculated.
- The quantities are chosen so that the faecal egg-count can be easily derived by multiplying the number of eggs under the marked areas by a simple conversion factor.
- The McMaster chamber has two compartments, each with a grid etched onto the upper surface. When filled with a suspension of faeces in flotation fluid, much of the debris will sink while eggs float to the surface, where they can easily be seen and those under the grid counted.

Materials required.

Two beakers or plastic containers, Balance, Tea strainer, cheesecloth or dental napkin,Measuring cylinder, Stirring device (fork, spatula, tongue depressor), Pasteur pipettes and rubber teats, Flotation fluid (choice of solution dependent on species expected to be present and availability of reagents), McMaster counting chamber, and Compound microscope

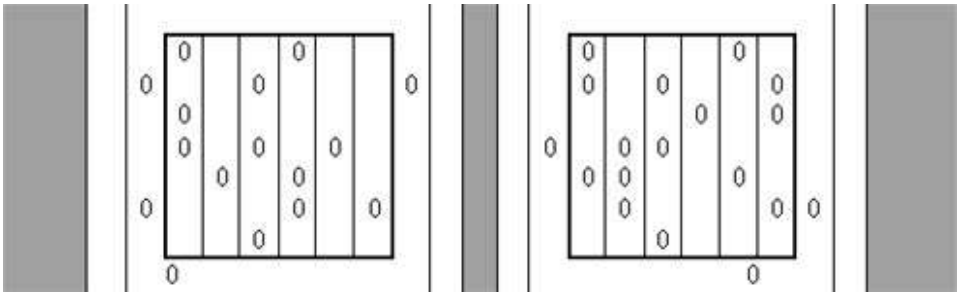
Procedure:

- Weigh 4 grams of faeces and place into a container.
- Add 56 ml of your chosen flotation fluid.
- Stir the contents of the beaker thoroughly with a fork, tongue depressor or spatula.
- Filter the faecal suspension through a tea strainer or double layer of cheesecloth or dental napkin into the second container.
- Stir the filtrate in container with a Pasteur pipette. Using the pipette withdraw a sub-sample as the filtrate is being stirred.
- Stir fluid and fill first compartment of the McMaster counting chamber with the sample. Stir fluid again and fill second chamber with another sample.
- Allow the counting chamber to stand for 5 minutes. It is important to leave the chamber to stand to allow the eggs to float to the surface and the debris to go to the bottom of the chamber.
- Examine the sample of the filtrate under the compound microscope at 10X magnification.
- Identify and count all eggs within the engraved area of both chambers.

The number of eggs per gram can be calculated as follows:

- Count the number of eggs within the grid of each chamber, ignoring those outside the squares.
- Multiply the total by 50 – this gives the eggs per gram of faeces (e.p.g.)

For example:



12 eggs were seen in chamber 1 and 15 eggs were seen in chamber 2

= (12 +15) x 50 = 1350 EPG.

Do not delay reading the count beyond the recommended time as the flotation fluid may distort or destroy delicate eggs. Therefore, it is advisable to only process a few samples at a time.

Stoll Egg Counting Technique:

A method for determining the number of nematode eggs per gram of feces to estimate the worm burden in an animal. The advantage of this technique is that it requires no specialized equipment, the disadvantage is the counting takes a long time because of the amount of extra (non-egg) material on the slides.

Procedure:

- Weigh out 3 grams of faeces.
- Measure out 42 ml of water and place it into a dish. Using a tongue depressor, push the 3 grams of faeces through a sieve into the water. Lift the sieve and hold over the dish. Push out any remaining water from the faeces.
- While stirring the water-faeces mixture, take 0.15 ml of the suspension and spread over 2 slides. Cover each slide with a long coverslip (or 2 regular size coverslips).
- Examine both slides for worm eggs, the total number of eggs counted X 100 represents the number of eggs per gram of faeces.

Calculation:

0.15 ml is 1/300 of 45 ml (42 ml water and 3 g feces) so the number of eggs in 0.15 ml X 100 is equal to 1/3 of the total number of eggs in the original 3 grams and thus equal to eggs per gram (EPG).

Skill Set (VETY) 20: Sensory evaluation of milk and meat products

Sensory Evaluation Principles and Major Considerations:

- Sensory evaluation is defined as a scientific discipline used to measure, analyze, and interpret reactions to those characteristics of food as they are perceived by the senses of sight, smell, taste, touch and hearing.
- It is the conscious effort to identify and judge different sensations and components in an object, be it a piece of food, a beverage, or a perfume.
- Sensory evaluation encompasses all of the senses.

- It considers several different disciplines but emphasizes the behavioural basis of perception.
- It involves the measurement and evaluation of sensory properties of food and other materials.
- Human judges are used to measure the flavour or sensory characteristics of food.
- In short, sensory evaluation is a very "Gestalt" approach to product assessment.

The major factors that influence the effectiveness of sensory evaluation are:

- Sample
- Panellists
- Environment
- Presentation

Considerations Pertaining to Samples in Sensory Evaluation

- Temperature of Samples
- Sample Size
- Sample Coding
- Order of Presentation
- Number of Samples
- Time of Testing
- Rinsing

Different Methods and Uses of Sensory Evaluation:

The three major types of tests utilized in undertaking sensory evaluation are

- Discrimination Tests
- Descriptive Tests
- Affective Tests

Discrimination Tests:

Discrimination Tests are used to determine whether a difference exists between samples. The panelist does not allow his personal likes and dislikes to influence his response. Laboratory difference panels are used to determine if there is a difference among samples.

Examples of these tests include.

- Paired Comparison
- Triangle tests
- Duo-trio
- Ranking Tests

Descriptive Tests:

Descriptive tests are used to determine the nature and intensity of the differences. It requires trained panels. Examples of these tests include.

- Rating or Scoring

- Texture and Flavour Profile Analysis
- Quantitative Descriptive Analysis

Affective Tests:

Preference tests are affective tests based on a measure of preference from which relative preference can be determined. Examples of these tests include Hedonic test - This is the one most commonly utilized in assessing meat and meat products.

Eating Quality of Milk/Meat products:

Few foods can match the extraordinary gustatory satisfaction derived by the consumer, consuming meat and milk products, a fact well exemplified by the continued existence of animal sourced foods as the central items of the diet in most affluent societies despite the advent of several nutritionally comparable meat and milk analogues.

The palatability includes factors such as colour, flavour, juiciness, tenderness/texture and overall acceptability.

Skill Set (VETY) 21: Open method of castration in pigs

The open method of castration in pigs is a common procedure performed to prevent unwanted breeding and improve the behavior and meat quality of male pigs.

Procedure:

Preparation:

- Gather all necessary equipment including a scalpel, surgical scissors, antiseptic solution, surgical gloves, and sutures.
- Ensure the pig is restrained properly to minimize movement and stress during the procedure.
- Administer anaesthesia or sedation as necessary to minimize pain and discomfort.

Sterilization:

Sterilize the surgical area by scrubbing it with an antiseptic solution to reduce the risk of infection.

Incision:

Make a small incision in the scrotum using a scalpel. The incision should be large enough to allow access to the testicles but small enough to minimize bleeding and trauma.

Testicle Removal:

- Carefully locate each testicle within the scrotum.
- Gently pull the testicle out of the scrotum and sever the spermatic cord using surgical scissors or an emasculator. This process should be repeated for each testicle.
- Some practitioners may use a rubber band or ring to cut off blood supply to the testicles, causing them to eventually fall off. This method, known as "banding," is less common in pigs compared to other livestock.

Hemostasis:

Ensure that any bleeding is controlled by applying pressure or using surgical techniques such as ligatures or cauterization.

Closure:

Close the incision using sutures or surgical staples to facilitate healing and reduce the risk of infection.

Postoperative Care:

- Apply a topical antiseptic to the incision site to further prevent infection.
- Administer pain relief medication as necessary to alleviate discomfort.
- Monitor the pig closely for signs of complications such as excessive bleeding, infection, or discomfort.

Recovery:

Allow the pig to recover in a clean and comfortable environment, away from other pigs to prevent excessive activity or aggression.

Follow-up:

- Monitor the pig's progress during the recovery period and provide any additional care or treatment as needed.
- Follow any specific guidelines provided by a veterinarian or experienced swine management professional.

Record Keeping:

Keep detailed records of the castration procedure, including the date, method used, any complications encountered and postoperative care provided.

Skill Set (VETY) 22: Spaying a female dog (bitch)

Indications for spaying in bitch:

- Elective sterilization
- Ovarian disease.
- Uterine disease.
- Behavioural problems.
- Vaginal hyperplasia.
- Prevention of mammary tumour.

Anaesthesia and Control:

General anaesthesia and supine position or lateral recumbency.

Site:

- Midline post-xiphoid.
- On either flank or single long incision on right flank, parallel to the last rib, below the lumber transverse processes, at the level of the posterior lobe of the kidneys.

Surgical Anatomy:

Ovaries lie close to the caudal pole of corresponding kidneys. Ovaries are covered with bursa and attached to the cranial ends of the uterine horn by the ovarian ligament. Ovaries are attached to the transverse fascia near the vertebral end of the last rib by suspensory ligament. Blood supply to the ovary is through ovarian artery and vein, which is a branch of aorta at 4 th lumbar vertebra. the vein drains the cranial end of the horn of uterus and the artery anastomoses with the uterine artery. Uterine artery comes from the urogenital artery and enters the caudal part of the broad ligament at the plane of the cervix and lies close to the caudal part of the uterus. It gives 8-10 branches to the uterus and anastomoses with the ovarian artery.

Surgical technique:

- Take a 2-3 cm long incision on the midline behind the umbilicus. Incise skin, subcutaneous tissue, Linea alba, falciform ligament and peritoneum.
- Introduce an ovariectomy hook or index finger towards the left flank and the uterine horn or broad ligament is withdrawn from abdomen.
- Apply three artery forceps, first close to the ovary to hold severed vessels, middle one to hold stump from the kidney, and last, towards the kidney, in between the above two artery forceps, to form groove for ligature.
- A double ligature with chromic catgut size 1-0 is placed on ovarian pedicle and the pedicle is cut between the first and middle artery forceps.
- Haemorrhage is checked carefully. Similarly, the right ovary is removed.
- The body of the uterus is then withdrawn from the abdomen uterine vessels are ligated on each side and one ligature is applied to encompass the entire cervix.
- After that the broad ligament is cut then severe uterus just cranial to the ligatures.
- Check the uterine stump for haemorrhage and returned it into the abdomen. Close the abdominal incision in the usual manner.

Skill Set (VETY) 23: Methods of injection of medicines to animals

Introduction:

Medicines are given to treat or prevent illness. They come in lot of different forms and taken in different ways.

Routes of Drug administration:

- Oral
- Parenteral
- Local

Oral Route:

The oral route of drug administration is through the mouth. Drugs in the form of bolus, pills, capsules, powders, and electuaries are administered orally. This route is commonly used in poultry and simple stomach animals. The bioavailability of drugs given by this route is however unpredictable due to

- Dilution of drugs in rumen contents
- Inactivation of drug by the microbes/ fermentation.
- Antimicrobial given orally can also affect the microbial flora.

However, certain drugs like anthelmentics and anti-diarrhoeal are mostly administered orally. Drug administered through oral route should preferably be palatable to save manpower which otherwise is wasted for restraining and feeding the drug. Animals accept it when mixed in feed or water. If poultry medicine is added in water, it should be soluble in water and should not be settle in bottom.

Advantages:

- Easy procedure.
- Preparation not to sterile.
- Minimum danger preparation can be used.
- Easy to treat a large number of birds and animals (making drugs in water/feed)

Disadvantages:

- Animals may not be always cooperative hence, it may be difficult to administer in some animal
- Unsuitable if animal is vomiting
- Correct dose is not possible
- In struggling animal, there is risk of aspiration pneumonia
- Oral antibiotics can affect microbial flora causing side effect
- Inactivation of certain drugs in gut by gastric acid
- Unsuitable for irritant and unpalatable drugs
- Delayed onset of effect due to absorption. Usually time required for absorption of drug is 1-3 hours in simple stomach animal and 30 minutes in poultry.

Parenteral Route:

Systemic of drugs away from the GIT is called parenteral administration

Advantages:

- Easier than oral dosing in some animals
- Onset of action is rapid and reliable
- Can be adopted in unconscious animals and those with emesis and diarrhoea
- Inactivation of the drugs in the GIT can be avoided.

Disadvantages:

- Dose must be very accurate
- Risk of inducing adverse effects or toxicity in sensitive animal
- Possibility of pain/irritation at the site of injection
- Drug solution must be sterile and pyrogen-free
- Aseptic precautions must be followed

Different routes of parenteral administration:

- Inhalation: Gaseous or volatile drugs are administrated by inhalation
- Injection: Drugs are administrated by injecting it into the body using various routes.

The following routes are the various routes for injections:

1. Intra–venous route (IV):

It is done by delivering drug solution directly into bloodstream by injecting it into the superficial veins. Large volumes of drug solutions and irritant/hypertonic drug solutions can be safely given by this route. This route has an instant onset of action. Disadvantages include embolism, anaphylactic shock, and phlebitis due to irritation of the drug solution.

2. Intra-muscular route (IM):

It is the injection of drugs into muscle mass. Soluble/ mildly irritant/ oil suspension is injected by the route. The disadvantages are local reaction at the site, risk of injecting drug solution near or into nerve causing reversible/irreversible paralysis. Aqueous solutions are rapidly absorbed, and oily suspensions are slowly absorbed.

3. Subcutaneous route (SC):

The drug solution is injected into the subcutaneous space. This route injects non- irritant solutions. The subcutaneous route serves as a drug depot and ensures sustained effects. Most of the vaccines are administered by this route.

4. Intra-dermal route (ID):

It is the injection of drug into layers of skin. Mostly used for diagnostic purposes. e.g. Tuberculin testing, allergic skin testing.

5. Intra-arterial injections:

It is the injection of drugs into arteries for diagnostic purposes. e.g. Angiography.

6. Intra-peritoneal injection:

It is the injection of drugs in the peritoneal cavity. Large volumes can be injected. This route is preferred when I/V injections are not possible and essentially in very small animals and for peritoneal dialysis.

7. Epidural:

It is the injection of drugs into epidural space. Generally, local anesthetics like lignocaine, are given by this route.

8. Intra-thecal:

It is the injection of drugs into the subarachnoid space for treatment of brain infections.

9. Intra- tracheal (IT):

It is injection of drug into tracheal lumen through tracheal rings. e.g. in pneumonia or cough in dogs.

10. Intra-cardiac (IC):

It is the injection of drug into the heart directly as an emergency procedure (Adrenaline).

11. Intra- articular (IA):

It is injection of drug into joint capsule in treatment of joints affections.

12. Intra – osseous:

It is injection of drug into the marrow of a bone.

Local Administration:

- Pour-on preparation: It includes application of dusting powder, lotions, ointments, fomentation with medicated water and giving bath in treatment of skin diseases.
- Introduction of pessaries in the vagina and suppositories into rectum or vagina and in case of uterine or vaginal drugs
- Enema: Retention and evacuation.

Other Routes:

Transmucosal Administration:

Sublingual: The tablet is placed under the tongue and allowed to dissolve in the mouth.

Trans –rectal: Pressing drug into upper rectum to avoid GIT irritation or in case of persistent vomiting

Intra-mammary (IMM): Introduction of drug into udder through the teats sphincter in treatment of mastitis.

Transcutaneous Administration:

Iontophoresis: Galvanic current is used to bring about the penetration of drugs deeper tissue.

Jet injection: Trans-cutaneous introduction of the drug using high velocity (jet) through injection is without a needle and is painless (e.g. insulin in man).

Table 1: Topical forms of drug and their description

Sl.no	Drug form	Description
1	Aerosol	Drug suspended in solvent and packaged under pressure.
2	Cream	Drug suspended in water – oil emulsion.
3	Gel	Drug suspended in semisolid or jelly-like substance.
4	Liniment	Drug suspended in oily, soapy or alcohol based substance applied with friction.

5	Lotion	Drug suspended in liquid for dabbing, brushing, or dripping on skin without friction.
6	Ointment	Drug suspended in semisolid, lipid-based preparation that melts at body temperature.
7	Paste	Drug suspended in semisolid preparation that retains its state at body temperature.
8	Powder	Drug suspended in powder for external lubrication or absorption.

Skill Set (VETY) 24: Glucose estimation with glucometer

Portable blood glucose meters (PBGMs) or glucometers are small electronic devices that measure the concentration of glucose in the whole blood.

Measurement of glucose concentration is carried out in a small blood volume, and it is comparatively simple, quick, and inexpensive to perform. PBGMs are frequently used in companion animal medicine, especially for the diagnosis and treatment monitoring of dogs and cats with diabetes mellitus and hypoglycemia.

The main factors affecting the precision of the measurement include:

1. The device (manufacturer), the consumables (reagent strips), and their storage conditions

2. Environmental conditions (temperature and possibly altitude)

3. Sample Collection technique (site of sampling, cleanliness at the site of sampling, use of anticoagulants)

4. Patient factors (hematocrit, blood triglycerides, creatinine, uric acid and protein concentrations, drug administration)

5. Handlers errors.

Due to the above factors, interpretations of glucose concentration by PBGMs may differ from those of the chemistry analyzers, and the results should be interpreted along with the clinical signs and any other laboratory findings for ideal diagnostic and therapeutic decisions.

Materials Required:

Commercially available Glucometer, cotton ball or a gauze, and Shaving blade

Site for collection of blood samples for glucose estimation:

Both capillary and venous blood can be used for the blood glucose test /estimation.

1. Ear pinnae or

2. Carpal/metacarpal pads

The most frequently used site for capillary blood sampling in dogs and cats is the lateral margin of the ear pinnae or the inner surface of the pinnae.

Methods of glucose estimation:

When capillary blood sampling is selected, the reagent strip of the PBGM is directly touched to the drop of blood on the animal's skin, and when venous blood is used, a drop of blood from the syringe

can be placed on the covering of the strip or a drop can be formed on the adaptor of the syringe after the removal of the needle tip as shown in Figure 1.

Figure 1. After venous blood sampling, the needle has been removed from the syringe, and the reagent strip of the portable blood glucose meter is loaded using the drop of blood that has been created on the adaptor of the syringe.

Capillary Blood collection may be facilitated by shaving (lateral margin technique), warming the puncture site for 30-60 sec with a damp cloth, holding a cotton ball or gauze under the pinnae and pricking close to but not onto a visible vein as shown in Figure 2.

Other alternative sampling sites for blood glucose testing are the carpal (pisiform or wrist) non-weight-bearing pads of dogs and the metacarpal pad of cats. Sampling is easier if the site is pre-warmed and lightly pinched with two fingers for a few seconds before and after puncture until an adequate blood drop forms as shown in Figure. 3. For this procedure, instead of the available lancing device, a hypodermic needle may be more appropriate.

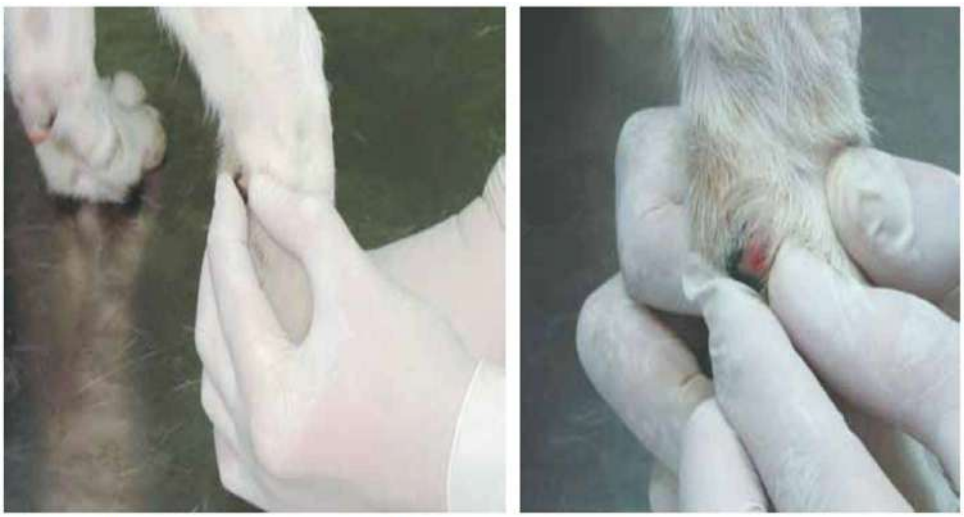


Figure 3. Capillary blood sampling from the carpal pad of a dog for measurement of blood glucose concentration with a portable blood glucose meter: a) the sampling site is pinched with two fingers; b) a drop of capillary blood appears immediately after lancing.

Care should be taken while performing the test as the presence of any contaminants at the site of sampling, even in trace amounts, can significantly raise blood glucose. Therefore, cleaning of the sampling site for dogs and cats should be carried out. However, the use of any disinfectant should be avoided, until any possible effect of the substance on glucose measurement is excluded.

Skill Set (VETY) 25: Semen collection in bull

Several methods have been developed for semen collection in animals. The methods of collecting semen have undergone several changes and mass changes have been made towards improving quality and quantity of the preserved semen.

Semen collection in bulls

Different semen collection methods in bulls are -

- Collection from vagina
- Massage technique.
- Artificial vagina method
- Electro ejaculator method

Vaginal method:

- The simplest and earliest method of semen collection was from vagina.
- In this method, the bull is allowed to mount the cow in or out of heat naturally and the semen is collected from the vagina using a spoon or syringe with a long nozzle.
- This technique is unsatisfactory because a selectively small volume of semen is mixed with a large volume of vaginal mucus.
- To avoid this female out of heat can be used. But this method requires the cow to be healthy and free of diseases.

Massage technique:

Here semen is collected by massaging the ampulla and seminal vesicle through per rectum. This method was reported as early as 1925 by Case and late well-described by Miller and Evans (1934).

Procedure:

- Before starting semen collection by massage method ensure that the bull has not ejaculated either by natural service or by some other method for two to three days to ensure that ampulla is full of spermatozoa.
- Secure the bull in a suitable stanchion.
- The preputial hair should be clipped.
- By tapping the preputial sheath stimulate the urination and empty the bladder
- Properly wash the preputial sheath with warm water and carefully dry it with a clean towel.
- The operator should trim his nails quite closely can pass his hand into the rectum after wearing a clean rubber sleeve on his arm and remove all faeces from the rectum

- The operator can carefully massage the seminal vesicle, prostate, and cowper's gland to stimulate some secretion of seminal fluid to rinse the bull's urethra.
- The seminal vesicles are gently massaged for few times with fingers by backward and downward strokes towards the urethra and a cloudy fluid is expelled.
- Then the ampullae are pressed one by one by the same slow and rhythmic manner.
- The ampullae are squeezed/ stripped by pressing over the floor of the pelvis and the pelvic urethra may be massaged.
- The massage can be done for 5 minutes. After the massage of the ampullae, the S-curve of the penis should be straightened to allow the escape of semen.
- An assistant holding a glass funnel leading to a collection vial directly beneath the bull's sheath can collect the semen during massaging.
- The quantity of fluid collected from seminal vesicles ranged from 0.5 to 21 ml and ampullae ranged from 0.5 to 23 ml**.**

Artificial vagina (AV) method:

The AV method of semen collection has replaced all the old, cumbersome, and unreliable procedures. The AV provides the most satisfactory method of collecting semen from bulls.

History and type of artificial vagina

- Russians (Kumorov and Nagev, 1932) designed the first artificial vagina. Various workers made different types of AVs.
- The Cornell University workers developed the Cornell Model and in US "Danish model" was developed.
- In tropical countries the "short model" was developed

Parts of Artificial Vagina:

Outer Hard Rubber cylinder, Inner thin rubber liner, Rubber band, Directors/rubber cone, Collection vial, and Insulation bag

Preparation of Artificial Vagina:

- The parts AV should be sterilized before its used for semen collection to avoid the contamination and disease transmission.
- After sterilization all parts should be dried and stored in a dust free cabinet or incubator.
- The inner liner should be inserted into the AV and both the ends are turned back over the ends of the cylinder.
- Rubber bands may be attached on both the ends so as to form a jacket between the liner and rubber cylinder.
- The director cone is fastened over one end of the AV and the glass semen collecting vial is attached to the smaller end of the cone.
- After assembling AV, half the jacket is filled with warm water of about 65-70ºC is poured to get the final temperature of 42.5 to 45 ˚C inside the AV. The remaining half of the jacket is filled with air. The temperature of AV may vary depending upon the season, time semen collection and air temperature.

- The insulation bag is used in colder or hotter environments to avoid cold/heat shock to the spermatozoa.
- The insulation bag is applied to cover the director cone and collection vial.
- After assembling the AV, sterile lubricating jelly is applied for 3 to 5 inches of the interior of liner.
- Excessive lubrication will cause contamination over semen samples by carrying the jelly through the AV over the bull's pelvis.
- Lubricants may be
    - K.Y. Jelly
    - Sterile white Vaseline jelly
    - White mineral oil
    - Tragacanth gum (3 g Tragacanth, 5 ml glycerine and 50 ml distilled water)

Preparation of bull

- Semen collection is done in the early morning. The animals will be active, and the stomach will be empty in the morning hours which help in better semen collection.
- The scheduled bulls will be carried from their paddocks to the washing area.
- The animals should be washed to remove all the dirt.
- They should be tied surrounding the collection shed and should be dried.
- The bulls should be tied with a bull apron and the prepuce should be cleaned with normal saline.
- The bulls are allowed to watch the other bulls mounting which will stimulate the bull. The forward and backward movement of the dummy will also stimulate the bull.
- The protrusion of the penis from the prepuce will indicate the bull is ready to mount.

Semen collection:

- The teaser should be restrained in a chute.
- The bull is allowed form behind the teaser and 2 to 3 false mountings are given.
- The right-handed operator can approach the bull from right side by holding the AV on his right hand
- When the bull mounts and ready to make the thrust, the operator using the left hand drawn the penis from sheath and directs it into the AV which is held at an angle that it is in have with the testis.
- During the entire process the testis itself should not be touched as it will leads to refusal to service
- The AV should be directed in such a way that the semen should be ejaculated in director cone or directly on collection vial.
- On completion of the thrust the collection tube is immediately doubled back on the cone so as to exclude any semen that might has been deposited on testis should not enter inside the collection vial (as it carries bacteria from penis and sometimes lubricating jelly)

- After collecting the semen, the collection vial is disconnected immediately, closed with clean stopper / sterile aluminum, plastered with details of bulls, placed in a beaker containing water of about 34 º C and examined as soon as possible.

Electro ejaculator method:

- Electrical stimulation of ampullae and seminal vesicles is also a method of collecting semen from bulls.
- Many instruments have been devised for the collection of semen through electro ejaculation.
- This method was used by Gunn in 1936 for rams. Later it was modified by Rowson and Murdock, Marden, Dzuik for collection of semen in bulls.
- Thibault *et al*. (1948) successfully used this for bulls.
- The instrument consists of a rectal probe with paired rings of copper.
- There are 30 rings which are insulated from each other with ebony.
- Sixty cycles alternate current is used. Voltage is increased rhythmically and returned back to zero in 3-5 seconds interval.
- The next increase will be higher than the previous one. A bipolar electrode was devised by Dzuik *et al.* (1954) for collecting semen.
- At one end it contained 6 metal rings spaced 4.5 cm apart. These metal rings work alternate as positive and negative electrodes.

Procedure:

- The animal is restrained in a Travis/chute.
- The rectum of the animal is flushed with normal saline.
- The preputial hairs may be clipped, washed, and dried.
- Teasing or sexually stimulating the bull before applying electro-ejaculate may help to inform the quality and quantity of semen.
- After cleaning the rectum, the glove hand with the electrodes is inserted and passed forward up to 30 cm and the electrodes can be pressed down on the floor of the rectum directly over the two ampullae between the two diverting seminal vesicles.
- An alternate current is passed starting at 5mvolt and return back to zero every 5 to 10 seconds.
- Subsequent stimulation should go high and again come back to zero.
- This gradually increased. Generally, the erection and ejaculation occur at 6-8 m volts.
- The semen is collected in a clean sterile glass with a glass funnel.
- The first portion generally consists of merely the watery secretion of the accessory glands and can be discarded.
- The portion usually containing semen is collected and used.

Skill Set (VETY) 26: Semen collection in boar

Boar training for semen collection:

A boar at 7 to 8 months of age is preferable for training. The boar should possess specific breed character, sound body conformation and be free of any defects or abnormalities. Initially the boar is to be shifted to a separate pen for about two weeks before they are exposed to training. Gradually boar is exposed to a "Dummy Sow", painted with fresh semen, at regular time intervals in the morning. Special attention is to be given so that the boar gets full liberty to play with the dummy. Making of breeding sound by the operator during training enhances the response towards dummy sow. Once the boar mount over the dummy sow, operator should hold erected penis at the twisted end with efficient pressure. The boar will start ejaculation if it feels comfortable. A three to four-day regular collection of semen from the first collection is essential to make the boar habitual for the job.

Semen Collection procedure:

- Place double layered filter (mira cloth/pasting paper) inside the Buchner funnel container and fit it with semen collection pre (38 ºC) warmed thermos flask.
- The trained boars are allowed to mount on a dummy sow and semen collection is done when he achieves the orgasm by holding his glans penis in the covetail grooves of the fingers made within the fist with an intermittent pulsatile pressure. If necessary, squeeze fluid from the "pouch" located near the sheath opening before actual collection. Avoid contaminating the ejaculate with these fluids. (Use poly vinyl gloves, not latex gloves during collection).
- Always discard the first part of the ejaculate (pre-sperm). It is clear, watery fluid and does not contain sperm, but it may have a high load of microbes.
- Collect sperm-rich fraction into the pre-warmed container. It will be very chalky in appearance and contains 80-90% of all sperm cells in the ejaculate. Collect this fraction until it changes to a clearer, watery fluid. Once you are certain the sperm-rich fraction is complete, continue collecting but discard the remainder (post-sperm) of the ejaculate.
- Always allow the boar to complete his ejaculation (5-8 minutes). Remove the filter with gel and discard. Cap the collection container transport it to the processing lab as early as possible. Attempt to schedule procedures so that the ejaculate is extended within stipulated time after collection.

Skill Set (VETY) 27: Artificial insemination of animals

Artificial insemination (AI) is a process of collecting semen from elite male animals like bulls or boars, processing and depositing it into oestrus female reproductive tract (cervix/ or uterus) manually with the help of a catheter. Both collection and insemination are accomplished through artificial means. Attention must be paid to minimize the interference to normal biological processes in order to achieve success.

Advantages of AI:

- Rapid genetic gain is achieved through extensive use of semen from genetically superior males.
- Widespread use of superior male germplasm to produce genetically upgraded progenies/piglets.
- Inbreeding can be checked through artificial insemination.

- Enable mass breeding of oestrus synchronized females through AI.
- Minimizes the spread of sexually transmitted diseases.
- AI make selective breeding easier as semen from a proven male can be easily transported to distant places and can be used for insemination of female on a large scale.
- Eliminates the cost of maintenance of breeding male & breeding cost.
- Introduction of new genetics possible through crossbreeding.
- Mating of animals of different sizes is possible through AI.
- Avoids possible injuries on either the male or the female that may happen during mating.
- AI gives chance to examine health status of the breeding female animal.

To get optimum results through AI, the technician should be knowledgeable, observant and should complete the AI procedure cleanly and accurately keeping in view of the hygienic and other important precautions in handling the semen.

Technique of AI in cattle and buffalo:

- Wear protective clothing *viz.*, rubber, latex, or plastic disposable gloves, apron and gumboots.
- Load the AI gun with the required semen straw.
- Restrain the cow in oestrus properly and secure the tail on one side.
- Lubricate the left gloved hand with soap and water or with antiseptic barrier cream and pass the lubricated hand into the rectum and remove the dung from the rectum if necessary.
- Clean the exterior of the vulva with a cotton wool swab.
- Keeping the left hand inside the rectum, open the vulvar lips with the help of an attendant and then insert the insemination pipette well into the vagina first in an upward and forward direction and then in slightly downward and forward direction.
- Grasp the cervix properly through the rectal fold with the left hand.
- Direct the AI gun into the external or with the guidance of the thumb and then insert carefully into the cervix up to mid to deep cervix. For proper positioning first pass the AI gun through the cervix up to the body of the uterus where the tip of the gun is easily palpable per rectum.
- Push the semen with the right hand.
- Withdraw the insemination pipette and then the left hand.

Technique of AI in Goat:

- Doe in oestrus is held properly by lifting the hind limbs by an attendant or placed in the specially designed insemination crate meant for goats and sheep.
- Load the AI gun with frozen semen straw (0.25 ml or 0.5 ml) and keep ready for use.
- Insert a sterilized speculum (stainless steel or glass vaginal speculum) lubricated with sterilized white Vaseline or liquid paraffin into the vagina by carefully turning it and then expose the os cervix
- Locate the cervix. Light source (headlamp or torch light) may be used to illuminate the os cervix properly.

- Insert the gun containing the semen straw through the speculum into the os cervix.
- Deposit the semen into the os cervix.
- Withdraw the speculum and then the catheter.
- Keep the hind quarter of the doe lifted for a few minutes (5 minutes) after the semen is deposited.
- Allow the doe to stand on the ground. Keep the doe away from male goats till the oestrus ends.

Frozen semen thawing procedure:

- Take water at 37°C in a glass beaker (500 ml) tall form or in a large size plastic goblet so that the frozen semen straw is completely immersed in water.
- Remove the lid of liquid nitrogen container containing frozen semen straw and identify the canister holding the straw.
- Cool the forceps (Long) by holding it on the LN_2 vapour.
- Lift the canister up to the bottom level of neck of the liquid nitrogen container.
- Immediately remove the straw with precooled forceps and lower canister back into the container.
- Transfer the straw into the beaker containing water (37°C) for 25-30 seconds (Before thawing of frozen semen inseminator must be sure that the animal is in proper heat and at best time of AI). See that the straw is fully in water.
- Remove the straw from water and dry it with tissue paper or muslin cloth. Read the straw and record the name, number of the bull with date of freezing printed on the straw.
- Hold the straw vertically; tap gently to raise the air bubble to the top next to the plug.
- If the pistolet is cold, warm up prior to use by rubbing in between the palms. Cold metal may damage semen.
- Pull back the piston or plunger of the AI gun (pistolet) about 6 to 7 inches and insert the straw into the barrel (canula) of the AI gun keeping the laboratory end or plug end of the straw outside. Cut the straw at right angle in the air space using sharp straight clean scissors.
- Place the sterile sheath over the AI gun. Fix the sheath with the barrel (canula) with the help of pistolet lock.
- Push the piston of the AI gun slightly so that a drop of semen appears at the tip of the AI gun. Now the AI gun is ready for insemination.

Artificial Insemination in Pig:

Artificial insemination in pigs is not common as in other farm animals. It is done with liquid preserved semen with a sperm concentration of 2-3 billion per dose (80-100ml). Pig semen is typically preserved at 15-18°C for 2-5 days in a BOD incubator depending on extender used.

Procedure:

- Check the sow/ gilt for true oestrus. Oestrus female will exhibit swollen vulva, vulval discharge, mounting on pen mates, off fed etc. Most important symptom is standing reflex while putting pressure on its back.

- Clean the vulva and perineal area with clean cloth/ cotton/ tissue or blotting paper.
- Take a sterilized catheter and lubricate the tip of the catheter with a sterile non-spermicidal gel for smooth insertion.
- Spread the vulva and gently insert the catheter upward and forward into the vagina and cervix by anticlockwise rotation until resistance feel. The spongy part of the catheter will get locked into the cervix.
- Fit the semen bag tightly into the open end of the catheter. Hold the semen bag in upward direction with one hand and stimulate the pig simultaneously with another hand. Stimulate the pig in a way that mimics the action of a boar by giving pressure on its back, stimulation of the flanks and gentle massage of the udder.
- Squeeze the empty semen bag just after completion of flow of semen into the tract to prevent backflow of semen. Stimulate the pig for 1-2 minute then remove the catheter slowly and gently by rotating clockwise direction.

Skill Set (VETY) 28: Enumeration of total erythrocyte

Counting of erythrocytes and leucocytes is done by Haemocytometer.

Principle:

A measured quantity of blood is diluted with isotonic solution (which will prevent hemolysis of erythrocytes) and placed on haemocytometer counting chamber and number of cells are counted under high power of microscope.

Haemocytometer:

A routinely used haemocytometer is an apparatus, which consists of a thick glass slide having two counting chambers, a cover slip, and two pipettes for the enumeration of erythrocytes and leukocytes. The thick glass slide is divided into three platforms, two laterals and one central with the help of trenches. The central platform is $1/10^{th}$ mm lower than the lateral platforms. The central platform is further divided into two halves with the help of a trench giving an ‘ H’ shaped appearance. Each subdivision of the central platform has improved Neubauer’s counting chamber for counting red and white cells of blood.

Each platform has a ruled area consisting of 9 primary squares, each square has an area of 1mm square. Each of the four corner primary squares is subdivided into 16 secondary squares to facilitate the counting of leukocytes. The central primary square is used for RBC counting and is divided into 25 medium squares each of which is further divided into 16 tertiary squares or small squares. The total number of tertiary squares in the central square is 400. The borders of secondary squares are made up of triple lines. It is customary to count all RBCs in five secondary squares i.e. four corners and the central one.

Materials:

Neubauer’s haemocytometer, tissue paper, microscope, and RBC counting pipette, which is marked as 0.5, 1.0 below the bulb, and 101 above the bulb & has a red bead in its blub. Blood is taken in the pipette up to 0.5 mark and filled up to 101 marks with diluting fluid, making the dilution 200 times.

Reagents required:

1. Blood sample, RBC diluting fluid. The diluting fluid should have the following properties:

- It should be isotonic to blood so does not cause lysis of the RBCs.
- It should contain a fixative so that it preserves the shape of RBC and prevent autolysis for longer period and makes it possible to count cells even after several hours of dilution.
- It should prevent agglutination of cells.

Different RBC diluting fluids are:

i. Gower 's solution

Sodium sulfate	12.5 gm
Glacial acetic acid	33.3gm
Distilled water to make	200ml

ii. Hayem's solution

Sodium sulfate	2.5gm
Sodium chloride	0.5gm.
Mercuric chloride	0.25 gm.
Distilled water to make	100 ml.

iii. Tossion's fluid

Sodium chloride	1.0 gm
Sodium sulfate	8.0 gm
Glycerine	30.0 ml
Distilled water to make	160 ml.

iv. Dacie's solution

Trisodium citrate	3.13gm
Distilled water to make	100 ml

Discard 1.0 ml and add 1.0 ml of 40% formaldehyde solution.

v. **Physiological saline**

Sodium chloride	0.85 gm

Distilled water to make 100 ml.

All these RBC diluting solutions should be used within three months of preparation.

Procedure:

Take blood up to the mark 0.5 and suck RBC diluting fluid up to 101 mark and mix it for two minutes by rotating between the palms. Place the cover slip over the haemocytometer and discard 2-3 drops of the fluid from the stem of the pipette. Apply the tip of the pipette at the junction of haemocytometer chamber and cover slip such that diluted blood flows under the coverslip by capillary action. To facilitate the uniform flow, rotate the pipette slowly with your finger. Note that the counting chamber is filled without any air bubbles and there is no overflow into the grooves around the central

platform. Keep it for five minutes for the setting of cells. Count the cells in five small squares (four corners and one central square) of the central large square under high power of microscope. Count the cells on lines which touch left and lower margin and discard the cells which touches right and upper margins of the squares. Add the cells from all the five squares and calculate the TEC as follows.

Calculations:

Let the number of cells in five smaller square or 80 (16x5) small squares be = X

Then cells in 25 small squares or 400 (16x25) small squares or one large square =X/80x400

Area of large (primary) square is 1 sq mm.

Hence. No. of cells in 1sq mm area = X/80 x400

No. of cells in 1 cu mm = X/80 x 400 x 10

No. of cells in 1 cu mm of diluted blood = = X/80 x 400 x 10

Dilution of blood = 1:200 or 200 times

No. of cells in 1cmm of undiluted blood = X/80 x400 x10 x 200

RBCs are expressed as millions per cubic mm of the blood = X/80 x400 x10 x 200/cu mm

Normal range of TEC in different species of domestic animals:

Sl. No	Species	TEC millions/cu mm
1	Cattle, buffalo	5.0 - 10.0
2	Horse	6.5 – 12.5
3	Sheep	8.0 – 16.0
4	Goat	8.0 – 18.0
5	Pig	5.0 – 8.0
6	Dog	5.5 – 8.5
7	Cat	5.0 – 10.0
8	Fowl	2.2 – 4.1
9	Human being	4.0 – 6.0

Physiological variations in TEC:

1. Lowest after sleep and then rises gradually reaching maximum till evening.
2. Increases in muscular exercise.
3. Increases at high altitude and decreases at low altitude.
4. Increases with an increase in temperature.
5. Excitement and injection of adrenaline increase the TEC.
6. Decreases in haemolytic anaemia and poisoning.
7. Increased numbers of RBCs in blood is termed as polycythemia and decrease in numbers of RBCs in blood is termed as oligocythemia.

Precautions:

- Pipette and haemocytometer should be clean and dry.

- Exact measuring of blood up to mark 0.5 in the pipette and proper dilution of sample should be there.
- Wipe off the excess blood from the tip of the pipette.'
- There should be proper mixing of blood and diluting fluid.
- Proper filling of the counting chamber without any air bubble should be done.
- Discard 2-3 drops of solution from stem of the pipette while charging the haemocytometer

Skill Set (VETY) 29: Enumeration of total leukocytes (tlc)

Principle:

Blood is diluted in a special pipette with WBC diluting fluid which will hemolyze the erythrocytes and cytoplasm of leucocytes. These diluted cells are placed on haemocytometer and then counted under low power of microscope.

Materials required:

Neubauer's hemocytometer, cover slip, microscope, tissue paper, and WBC counting pipette, which is marked as 0.5, 1.0 below the bulb, and 11 above the bulb, the bulb has a white bead. Fill the blood up to 0.5 mark and diluting fluid up to 11 mark, which makes the dilution 1:20 i.e. 20 times.

Reagents required.

1. WBC diluting fluid, blood sample.

Different WBC diluting fluids are:

i. Turk's WBC diluting fluid

Glacial acetic acid	2ml
Gentian violet (1% aqueous solution)	1ml
Methyl violet	1 drop
Distilled water to make the volume	100ml

ii. Rees and Ecker's solution

Sodium citrate	3.8 gm
Formalin	0.2ml
Brilliant cresyl blue	0.5gm
Distilled water to make the volume	100 ml

This fluid is good for WBC counting in birds.

WBC diluting fluid should have the following properties:

- Should be hypotonic to blood i.e. it should cause lysis of RBC, cytoplasm of WBCs is dissolved, and their nuclei become prominent.
- Should have a fixative to fix WBC.

- Should have a stain to stain WBC.

The best results are obtained when these solutions are used within three months of their preparation.

Procedure:

- Fill the blood up to 0.5 mark in the WBC diluting pipette wipe off the blood adhering to the tip and outside of the pipette and draw the WBC diluting fluid to the 11 mark Mix the diluting fluid with blood by rotating the pipette in between the palms for two minutes.
- Then discard the first few drops from the stem of the pipette and put the cover slip on the haemocytometer.
- And then load the chamber of haemocytometer by touching the tip of the pipette at the junction of edge of haemocytometer and cover slip till the haemocytometer chamber is filled with the diluted blood without any air bubbles.
- Then allow the cells to settle down for five minutes. Then count the leucocytes under low power (10x) of the microscope in the four corner large squares (each having 1mm sq area).
- Count the cells that are on the left and lower margin of the square and discard the cells that are on the right upper margin

Calculations:

Let the number of leucocytes in four large squares = X

Average no. of leucocytes in 1 large sq. or 1mm sq area = X/4

No. of leucocytes in 1 mm^3 = X/4 x 10

No. of WBCs in 1 cu mm of diluted blood = X/4 x 10

Dilution of blood done = 20 times

No. of WBCs in 1 cu mm of undiluted blood = X/4 x 10 x 20.

So, the number of **leucocytes/ cu mm** of undiluted blood = X/4 x10x20=**X x50**

Sl. No.	**Species**	**TLC (x 10^3/cu mm)**
1.	Cattle & Buffalo	4.0 – 12.0
2.	Horse	5.5 – 12.5
3.	Sheep	4.0 – 12.0
4.	Goat	4.0 – 13.0
5.	Pig	11.0 – 22.0
6.	Dog	6.0 – 17.0
7.	Cat	5.5 – 19.5
8.	Fowl	20.0 – 35.0
9.	Human beings	5.0 – 10.0

Physiological variations:

- Leucocyte count is higher in young calves and dogs and low in pigs at birth.
- Exercise and asphyxia (lack of oxygen) show increased TLC.
- In morning or after rest TLC is lowest and rises as work proceeds and rises till evening.
- TLC increases in the later stages of pregnancy and the oestrus period.
- Excitement, emotional stress or adrenal injection and corticosteroid treatment show increased TLC.
- Bacterial or viral infections, inflammatory conditions, pain, allergic conditions etc. show increased TLC.
- Bone marrow abnormalities, injections of antibiotics, infections like leptospirosis, rickettsia and protozoa, and sequestration of neutrophils (accumulation of leucocytes at localized infections) show decreased TLC.
- Increased leucocytes count is termed as leucocytosis and decreased leukocyte count is termed as leukocytopenia or leukopenia.

Precautions:

- Pipette and hemocytometer should be clean and dry.
- Exact measuring of blood up to mark 0.5 in the pipette and proper dilution of sample should be there.
- Wipe off the excess blood from the tip of the pipette.
- There should be proper mixing of blood and diluting fluid.
- Proper filling of the counting chamber without any air bubble should be done.
- Discard 2-3 drops of solution from the stem of the pipette before charging the haemocytometer.

Skill Set (VETY) 30: Necropsy examination

Post-mortem Examination (PM) of carcass is conducted by a Veterinarian or a Veterinary Pathologist to ascertain the cause and nature of disease in fatal cases. The term autopsy is preferred in human medicine for PM examination and necropsy in veterinary medicine.

- **Autopsy** means seeing with one's own eyes.
- **Necropsy** means seeing a carcass.
- **Autopsist** conducts the PM examination

TYPES OF NECROPSIES:

a. Where no necropsy is conducted:

If the blood smear from ear vein (cattle, sheep and goats) or smear from oedematous fluid from the throat or abdominal region (pigs, horse) reveals anthrax bacilli no necropsy should be conducted on the carcass since the organisms are aerobic spore formers. The spores survive as long as 18 years.

S.No.	Particulars	Anthrax bacilli	Anthracoids
1.	Organism	*Bacillus anthracis*	Other than *B. anthracis*
2.	Capsule	Predominantly pink stained	Less predominant
3.	Spores	Absent	Present
4.	Length of chain	Usually 2 to 3 organisms	Long chains
5.	End of bacilli	Truncated	Rounded

b. Partial necropsy:

In the case of rabies, only the brain of the carcass is examined for diagnosis. Here only a part of the body (head) is opened for the purpose. Other parts of the body are not opened.

c. Complete necropsy:

All parts of the body are thoroughly examined to arrive at an etiological diagnosis.

d. Cosmetic necropsy:

Examination of the carcass is done with very little mutilation. Cuttings and incisions are sewn together and the body is washed to appear as nearly intact as possible. It is done in the case of pet and wild animals.

Necropsy as a factor in diagnosis:

Necropsy accomplishes bringing into open previously unseen or merely surmised lesions and even certain etiological agents not observable from the animal's exterior. Quite frequently, the necropsy may be compared with opening and reading a book, the title of which conveys a certain meaning; but it is the text that portrays the plot, the sequence of events, and the conclusions. The necropsy like the textbook may reveal items of a surprising or unexpected nature thus explaining previously unknown or baffling events.

Clinical diagnosis would be more accurate if the clinician follows the animal which failed to respond to therapy to the necropsy. The veterinarian holds a distinct advantage over the physician in the matter of post-mortem diagnosis since he/she may employ euthanasia in order to hasten the process of diagnosis.

Time of necropsy:

The post-mortem examination (PME) should be conducted as soon as possible after the death of the animal. If delayed, various PM changes including autolysis and putrefaction may set in which sometimes may confuse with morbid lesions and distort the diagnosis. However, even if PM changes have advanced considerably, still from a standpoint of gross pathology the deterioration is not as serious as many believed. If the disease was one that could have been diagnosed originally by gross pathological changes it probably can still be diagnosed by distinguishing PM changes from morbid lesions.

Place of necropsy and site for disposal:

The veterinary practitioner needs but little space for the conduct of necropsies. For small animals, a well-ventilated room of the hospital may be set aside for euthanasia and necropsies. In large animals, the veterinarian should choose an outdoor area least likely to allow contamination to spread. Sanitary conditions and the intended disposition of the carcass are factors that outweigh convenience in deciding where to perform the necropsy. If there is any possibility that the animal may have died of a

contagious disease, it is imperative to avoid contamination of ground accessible to susceptible livestock or their food.

If the necropsy has to be performed near a farm building or on ground from which livestock is not excluded, it may be feasible to have an extremely deep bed of straw prepared on which to place the carcass. The straw absorbs the fluids and can be burned or buried afterwards.

More frequently, it will be decided to transport the carcass to some distant field not used for livestock at least during the current year. If the animal is to be buried, a deep grave layered with lime can be dug where the carcass can be easily rolled into, to be followed by the contaminated layer of the earth.

Materials required:

Small and large scissors with either pointed or round ends, chisel and hammer, curved scissors, small and large knives, scalpel and blades, bone cutters and saw (small and large), small and large forceps, toothed forceps, hand lens, rubber or latex hand gloves, masks, Bunsen burner or spirit lamp or stoves, spatula, syringe and needles (Tuberculin syringe), sterilizer, autoclave, spirit or alcohol, cotton and cotton swabs sterilized, sterilized vials, Petri dishes and test tubes, Pasteur pipettes and rubber bulbs, tissue fixatives 10% formalin, formal saline, buffered neutral formalin, small or large stainless steel trays, monocular/binocular microscope.

Clean glass slides and coverslips, normal saline, and glycerine-saline, different staining solutions Ziehl Neelsen, Giemsa and Wright's and Leishman stains, match boxes, rubber apron, disinfectants including dettol, savlon, phenyl, iodophore etc: fly repellants, Coldwater, water container; small screw-top vials, water-tight jars, blotting paper, staining rack, sticker labels, marking pen, glass marking pencil, slide tray, monopan balance, physical balance/jeweler's balance, kitchen balance max. 5 kg with weight, measuring tape cm/inches, aluminum foil, adhesive tapes, towel soaps, measuring cylinder, centrifuge, record, ice box/flask, transport media for bacteria, transport media for the virus, antibiotic solutions (penicillin, streptomycin, gentamicin, and mycostatin), polypropylene bags, mask-disposable, thread, gum boots, camera with film, Postmortem stainless steel top table, rexin/rubber sheets, vials with anticoagulants.

Disinfectants:

Although not as effective as steam/heat sterilization, chemical disinfectants are usually employed for necropsy instruments, boots, and gloves as well as the tables and premises connected with necropsy. To be effective any such disinfection must be preceded by thorough mechanical cleaning. The commonly used chemicals are Lysol, cresol, chlorine, quaternary ammonium compounds, and mercury in the form of bin-iodide combined with potassium iodide, iodophores, phenol, etc. The choice of disinfectant to be used for the disposal of carcasses where the cause of death is suspected to be infectious and contagious (Anthrax) is quick lime.

Precautions:

- Obtain written permission from the owner before post mortem examination.
- Request from local police is a must in vetero-legal cases
- Conduct post-mortem as early as possible to avoid putrefaction.
- Examine the smear from peripheral blood to rule out anthrax. Besides anthrax bacilli, examination of blood smear may reveal blood parasites, other bacterial and/or post-mortem invaders.

- Post-mortem examination should be done in the daytime to appreciate the accurate changes in the colour of tissues. This is not possible with artificial light.
- Conduct post-mortem far away from animal houses and farm premises and preferably in government land to avoid litigation.
- Obtain history, symptoms and treatment done etc.
- Wear gloves, mask, aprons and gum boots to avoid contact with zoonotic agents.
- Record the post-mortem findings immediately.
- Bury the carcass in deep ditches layered with lime. Carcass can be burnt to ashes if incinerator is available.

Instructions to Students:

- Wear protective clothing, rubber gloves/shoes
- Do not wear a watch, ring, or bangles while conducting a necropsy.
- Each student is expected to have his/her own set of instruments (Scissors, forceps, scalpel)
- Hands may be washed frequently during necropsy.
- All accidents including minor cuts during the necropsy should be reported to a member of the teaching staff and medical attention sought.
- After completing the procedures, the gloves and instruments should be cleaned with the disinfectant provided.

Skill Set (VETY) 31: Postmortem examination of poultry

Selection of specimen:

The specimen should be properly selected. A few of each ailing, dead, and sometimes normal bird should be examined to have a true picture of the disease.

Killing of birds for p.m. examination:

Mostly two methods are employed-

i) **Breaking of neck:** The head is bent vertically upward by the thumb under the neck dislocating the skull from the neck and breaking the cord. But we should not pull off the head from the neck and stop pulling when separation is felt.

ii) **Euthanasia:** Phenobarbital solutions or other suitable anaesthetic agents can be injected or by placing the head of the bird in a narrow jar containing chloroform-soaked cotton with a pad.

Postmortem examination procedure:

- The dead bird is dipped in an antiseptic solution or water to avoid feather contamination.
- The bird is laid on its back.
- Each leg in turn drawn outward away from the body.
- Skin is incised between the leg and abdomen on each side.

- Both legs are then grasped firmly in the area of the femur and bent forward, downward and outward, until the heads of both femurs are broken free of the acetabular attachment so both legs will lie flat on the table.
- The skin is cut between the two previous incisions at a point midway between the keel and vent.
- The cut edge is then forcibly reflected forward, cutting at necessary, until the entire ventral aspect of the body, including the neck is exposed. Haemorrhages of the musculature, if present can be detected at this stage.
- A P.M. knife used to cut through the abdominal wall transversely midway between the kee and vent and then through the breast muscles on each side.
- Posting shears are used to first the rib cage and then coracoid and clavicle on both sides. With some care this can be done without severing the large blood vessels.
- The process can be done equally well in reverse order, cutting through (the clavicle and coracoid) the ribcage and abdominal wall on each side.
- The sternum and attached structures can now be removed from the body and laid aside. The organs are now in full view and may be removed as they are examined.

If a blood sample has not previously been taken and the bird was killed just before P.M. examination, a sample can be collected by heart puncture at any stage that the heart is exposed to view.

Examination of organs:

In cases where a bacteriological examination is required, the tissues and heart blood should be collected aseptically in sterile containers. Arrange the organs logically on the table and start examining the organs in whatever order preferred, but the gastrointestinal tract should be examined last.

Lungs:

- The lungs and associated lymph nodes should be inspected closely.
- Incise the trachea down its length from the larynx and examine.
- Make generous incisions through the different lobes.
- Squeeze the cut edges and examine for pus, blood or oedematous fluid.

Heart:

- Examine the pericardium, pericardial fluid and epicardium.
- Remove the pericardium.
- Locate the septum and open the right ventricle by incision adjacent to the septum.
- Pass the knife under the tricuspid valve into the pulmonary artery and open it.
- A similar procedure is carried out on the left side.
- Open the pulmonary vein by passing a knife through the bicuspid valve.
- Examine the heart valves, vessels, endocardium, myocardium, and epicardium.

Brain:

- Disarticulate the head at the atlanto-occipital joint.
- The skin and muscles are stripped off.

- Make a transverse cut behind the posterior margins of the orbits.
- Lateral cuts are made at an angle of 34-40 from a sagittal plane along the dorsal aspect of the cranium.
- The lateral cuts should meet anteriorly and posteriorly.
- Try up the calvarium and remove it with the help of a chisel.
- Severe the olfactory and optic nerves.
- The brain is lifted up from the front and removed.
- Examine the various parts of the brain for the presence of tumors, cysts, abscesses, parasites, haemorrhages, etc.

Digestive Tract:

- Open the digestive tract at various portions.
- Examine the bowel, bowel contents, and mucous membranes for abnormalities.
- Examine the mesenteric lymph nodes also.
- Remove the contents and examine for presence of parasites and lesions.

Paranchymatous Organs:

- Examine the liver, spleen, kidneys, etc. for gross changes.
- Incisions are made to determine the inner character of the organs.
- Examine various lymph nodes associated with these organs.

Genital Tract:

a) Female:

- Examine the ovary for any abnormalities.
- Open the fallopian tubes and examine them.

b) Male:

- Examine the testes (adult birds) for gross changes.

Skill Set (VETY) 32: Tissue processing for microsectioning techniques

Techniques:

- Paraffin embedding technique.
- Frozen section technique

Processing of tissue by paraffin embedding technique

1. Removal of fixative:

Fixative is removed from tissues by keeping them overnight in running water. If alcohol is fixative then go directly for dehydration.

2. Dehydration:

Removal of water from tissue is called dehydration. Alcohol is most commonly used as dehydrant. Other dehydrants are methanol, acetone and dioxane. Removal of water is done by passing the tissues in ascending grades of alcohol to prevent undue shrinkage of tissues.

- Ethyl alcohol 70% : 1 hours
- Ethyl alcohol 80% : 1 hours
- Ethyl alcohol 90% : 1 hours
- Absolute alcohol- I : 1 hour
- Absolute alcohol-II : 1 hour

3. Clearing:

During dehydration, water in tissue has been replaced by alcohol. As paraffin wax is not soluble, alcohol is replaced with a substance in which wax is soluble. This step is called clearing. i.e., removes alcohol from the tissues and prepare them for penetration by paraffin during embedding. A satisfactorily cleared tissue has a characteristic translucent appearance. The commonly used clearing agents are xylene, chloroform, benzene, toluene, cedarwood oil etc.

Xylene clears rapidly but time should be regulated precisely as the prolonged treatment makes the tissues brittle. Chloroform has the advantage of much less hardening effect, enable the paraffin in the mixture to partially infiltrate the tissue and rapidly evaporates from the pure paraffin bath. Benzene clears quickly, makes tissue more transparent and evaporates rapidly from the paraffin bath without much hardening. Cedar wood oil does not harden the tissues and clears from 90% alcohol, but penetration is slow and elimination from the paraffin bath is difficult. Xylene is cheap and quick in action – makes tissues transparent – causes shrinkage and hardening if tissues are kept longer. Other clearing agents like Cedarwood oil, toluene, benzene, and chloroform are expensive**.** The tissues are kept for 30 minutes for each of the two changes

Xylene I – 30 mins

Xylene II – 30 mins

4. Impregnation/ Infiltration:

It is the process by which tissue are surrounded by wax which when solidified will provide sufficient external support during sectioning. Paraffin wax with a melting point of 56-58^{0}C is commonly used. The duration of impregnation depends on size and types of tissue and the clearing agents employed. Longer periods are required for larger pieces and also for harder tissue like bones and skin.

5. Embedding/block making

First proper placement of tissues in melted paraffin, to make the paraffin blocks. No bubble should be around the tissue. Soon after embedding tissue in mould/L blocks, it should be transferred to the refrigerator. This is done to prevent crystal formation in paraffin. Apply little glycerin in mold or L block before putting paraffin to facilitate the removal of blocks from mold. Each block must be labeled. If “L” shaped moulds are used: the two L-shaped moulds are arranged in the form of a rectangle over a porcelain slab. Melted paraffin is poured into the mould and the tissue is so oriented that the cutting surface of the tissue faces the porcelain slab. The molds are removed as soon as paraffin sets.

6. Section cutting/ sectioning:

Sectioning is accomplished by using a cutting apparatus called a microtome.

Microtome: it is a mechanical instrument used to cut biological specimens into very thin segments for microscopic examination/it is a machine used for cutting micro sections. The varieties of microtomes are:

a. Rotary microtome: this is used exclusively for cutting paraffin sections. For this biconcave or plane-edge type knives are used. Types of rotary microtome:

i) Manual Rotary Microtome: completely manipulated by the operator.

ii) Semi-automated Rotary Microtome: one motor to advance either the fine or coarse hand.

iii) Fully automated Rotary Microtome: two motors that drive both the fine and coarse advanced hand wheel.

b. Rocking microtome: name derived from the rocking action of the cross arm. Oldest in design, cheap, simple to use, extremely reliable, and with minimum maintenance.

c. Sliding microtome: this is used for special purposes, mainly for cutting celloidin and paraffin material. The block remains stationary while the microtome knife moves during the process of sectioning.

d. Sledge microtome: in it the block holder is mounted on a steel carriage which slides backward and forward on guides against a fixed horizontal knife.

e. Freezing microtome: This is used exclusively to cut an un-embedded, unfixed frozen tissue. Sectioning is done on unfixed tissue. The microtome is housed in a deep freezer cabinet. The temperature can be maintained between -15 to -30^{o}C. The optimum cutting temperature is -20^{o}C

Procedure for section cutting:

1. Trim the block with a sharp scalpel making the upper and lower surface parallel.
2. Keep the blocks chilled on a block of ice/ refrigerator. (Mounted block and microtome knife should be at the same temperature while sectioning).
3. Mount the block to the block holder.
4. Slide the knife/blade carrier forward until knife/blade is just in front of the block. Make sure that both the upper and lower edges of the block are parallel to the knife edge.
5. Adjust the clearance angle of the knife/blasé between 15-10 degree.
6. Adjust the microtome indicator that regulates the thickness of the section (for trimming 10-20µ (micron), section cutting 3-6µ (approx. 5µ).
7. To cut the sections, revolve the fly wheel with an even and rapid motion.
8. When ribbon reaches a length of 6-7 inches detach it from the microtome by a small brush.
9. Sections are transferred to a tissue floatation bath having warm water (40 to 45^{0}C just below melting point of paraffin).
10. Sections spread out uniformly and are then taken on the clean glass slides thinly coated with Mayer's egg albumin (Mayer's egg albumin is a section adhesive, egg white: glycerin (1:1)).
11. After mounting, the mounted slides are transferred into incubator for overnight or at 60^{o}C for 30 mins.

Staining and identification of sections prepared from pathological lesions:

- Haematoxylin and eosin method of staining (H&E) is commonly employed.

H&E staining procedure:

1. Deparaffinize the section by passing through 3 sets of xylene 5-10 minutes each (Xylene I, II, III)
2. Hydration of the tissue is done by placing the slides in descending series of alcohol viz absolute alcohol, 90%, 80%, 70% for 1-2- mins each
3. Wash in tap water for 10 mins.
4. Stain with haematoxyl in for 10-15 minutes.
5. Wash in tap water.
6. Differentiate acid alcohol 3 to 10 quick dips. Check the differentiation with a microscope. Nuclei should be distinct and the background very light or colourless.
7. Wash in tap water briefly.
8. Dip in ammonia water or lithium carbonate water until sections are bright blue.
9. Wash in running tap water (if washing is inadequate eosin will not stain evenly)
10. Counterstain with eosin for 15secs to 2 mins until section appears light pink (Wash in tap water).
11. Dehydrate in 95% alcohol two changes 2 mins each
12. Absolute alcohol two changes 2 mins each
13. Clear with xylene two changes 2 mins each
14. Mount in Canada balsam or DPX Mountant
15. Keep slides dry and remove air bubbles, if any

Interpretation:

- Nuclei: Blue
- Cytoplasm: Pink

Identification of slides:

- Examine the slides under low power (4X, 10X objectives) for identification of organ and distribution of lesions.
- Use higher power objectives as and when needed to observe specific tissue/ cellular detail.

STEPS:

- Identify the organ/ tissue.
- Stain employed.
- Observe for any deviation from normal histological picture.
    - Tissue: architecture, infiltration, hemorrhage, congestion, proliferation and invasiveness etc
    - Cell membrane e.g. Whether discernable/visible or not

- Cytoplasm e.g., Staining character (increased eosinophilia), granularity, presence of vacuoles, inclusions etc.
- Nucleus with regards to structure as well as staining characteristic or presence of inclusion, mitotic figures etc. Some descriptive terms are:
    i. Pyknosis: nucleus shrunken (small, rounded) with condensed, homogenous chromatin which takes deep blue colour. Nucleolus is absent.
    ii. Karyorrhexis: nucleus broken into many fragments which remain at the original position of the nucleus or may be scattered.
    iii. Karyolysis: nucleus dissolved and hence not seen. A nuclear membrane may be present.
    iv. Chromatolysis: Stainable material of nucleus viz, nucleolus, chromosomes etc. seen.seen
    v. Mitotic figures: nucleus showing state of mitosis i.e., presence at various stages of division.

Skill Set (VETY) 33: Computation of ration for cattle and buffaloes

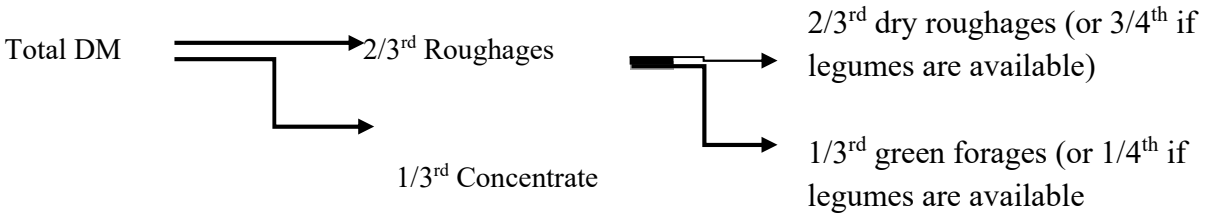
The following principles should be considered for formulating cattle and buffalo ration.

1. Ration should be well balanced. The animals should be fed twice a day. The interval between two feedings should be not less than 8-10 hours.
2. The animals should always be offered clean, digestible, palatable, and nutritious economic fodder.
3. The feed should invariably contain dry, green fodders and concentrates.
4. The straws and hays should be chaffed into small edible pieces and the grains may be crushed well and soaked in water before offering to the animals.
5. Sudden changes in the diet should be avoided as it results in digestive disturbance and reduction in milk yield in lactating cows and buffaloes.
6. To avoid mineral deficiency, adult animals should be offered 30-60g of salt daily.
7. The animals should be fed according to their body needs. Feeding less or in excess is detrimental to their health.
8. For maximum milk yield, the lactating females should be subjected to individual feeding.
9. Feeding troughs should be thoroughly cleaned before offering the ration to the animals.
10. Sufficient clean and fresh drinking water should be supplied to the animals.

Requirements of the dry matter:

In the computation of ration for cattle and buffaloes, it is necessary to ascertain and to meet the total requirements for 24 hours primarily in terms of DM. In general, cattle require 2.0-2.5 kg and for

buffaloes 2.5-3.0 kg of dry matter for every 100 kg body weight per day. Out of total DM requirement, 2/3rd should be met by roughages (of which 2/3rd dry and 1/3rd green) and remaining 1/3rd by concentrates. The same is shown diagrammatically.



Nutrient Requirement in terms of digestible crude protein (DCP) and total digestible nutrients (TDN):

From the nutritional point of view, the dry matter consumed is considered under two heads: digestible crude protein and total digestible nutrients. These two constituents are most important in animal feed. Hence the need for computation of the requirement of DCP and TDN. The requirement of DCP and TDN depends on the physiological needs such as for maintenance, production, and pregnancy. It is necessary to consider the quantity and quality of milk produced. Nutrient requirements of dairy animals (Cattle & Buffalo) for maintenance and milk production are given in the Appendix.

Procedure:

- Find out the total requirements of the animal in terms of DM, DCP and TDN depending upon the physiological status (pregnancy, lactation, growth, work, etc.)
- By trial-and-error method, find out the amount of green and dry fodder that should be offered to meet the nutrient requirements of the animal taking into consideration their availability.
- Calculate the amount of DM, DCP and TDN supplied through green and dry fodder.
- Now, subtract the amount of nutrients supplied through green and dry fodder from the total requirements of the animal to find out the balance of nutrients to be supplied through concentrates.
- Finally, calculate the amount of concentrate mixture to be offered to the animal to meet the balance of nutrients.

Note: Generally, rations are first formulated for one nutrient (say DCP) and then, the other nutrients (say TDN) are checked to see whether the feedstuffs used will meet the requirements or whether alternative feeds need to be included in the ration.

Computation of concentrate mixture Procedure:

Pearson Square Method:

1. Draw a Pearson's square fort determining the proportions (or) ratio of feeds to be mixed.
2. Partition the feeds as high protein and low protein feeds.
3. Place the percentage of crude/digestible crude protein desired in the center of Pearson's square.
4. Place the average percentage of crude/digestible crude protein present in high protein feeds on the left side upper corner of this square.
5. Place the average percentage of crude/digestible crude protein present in low protein feeds on the left side upper corner of this square.
6. Take about the diagonal lines in the square.

7. Draw the difference between the figures on the lsideand sides and the center figure and place these on the right-hand corners of the square, in the direction of diagonal lines.
8. The figures obtained on the right-hand side corners are the parts or proportions in which the ratio of the given feeds should be mixed to obtain the mixture of desired CP/DCP percentage.
9. Pass the feeds to be mixed through grinder and then mix the ground feeds in horizontal/vertical mixer.
10. Fill the gunny bags using the shovel (or) directly fill it from the mixer.
11. Label the feed mixture along with the weight neatly, clearly, and legibly.

Note: Minerals consisting of bone meal and common salt may also be added in required quantity before grinding and mixing.

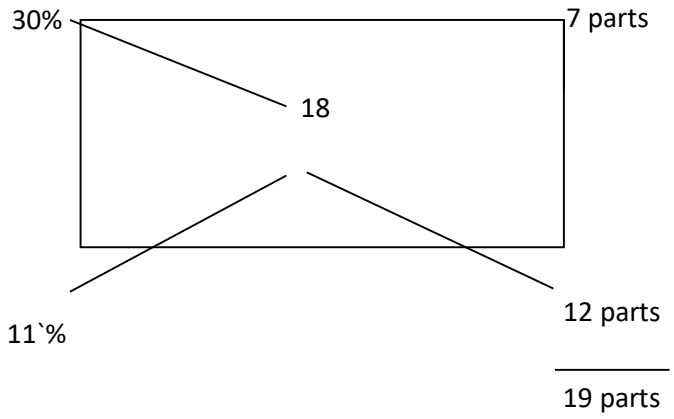
Example:

Prepare 100 kg concentrate mixture containing 18 % DCP using maize grain, wheat bran and linseed cake consisting of 10, 12 and 30 % DCP, respectively.

Solution: Average DCP of low protein feeds = Maize + Wheat bran/2

=10 + 12/2 = 11 %

DCP content of high protein feed (linseed cake) = 30 %



Therefore, amount of low protein feeds = 100 – 37 = 63 kg.

This should be distributed among the low protein feeds equally. Hence, amount of maize = 63/2 = 31.5 parts

Verification:

Feedstuff	Parts	% DCP supplied
Linseed cake	37.0	37 x 30 / 100 = 11.1
Maize	31.5	31.5 x 10 / 100 = 3.15
Wheat bran	31.5	31.5 x 12 / 100 = 3.78
Total	100	18.03

Example: Formulate a ration for a buffalo weighing 500 kg yielding 10 kg of milk / day with 7% butterfat and in 1st lactation using the following feedstuffs.

Feedstuff	DM	DCP	TDN
NB – 21 fodders	25	1	16
Paddy straw	90	0	40
Concentrate mixture	90	16	70

Solution:

1. Calculation of nutrient requirements of the animal.

Requirements	DM (kg)	DCP (kg)	TDN (kg)
For maintenance	12.5 – 15.0	0.30	3.70
For production	-	0.63	4.60
(10 kg with 7 % fat)			
Growth allowance	-	0.06	0.74
(20 %-1st lactation)			
Total requirements		0.99	9.04

2. Finding out the amount of nutrients supplied by green and dry fodder.

Feedstuff	Amount on Fresh basis	Dry basis	DCP (kg)	TDN (kg)
NB – 21 fodders	20	5.0	0.2	3.20
Paddy straw	6	5.4	0.0	2.40
Total quantity	26	10.4	0.2	5.60

3. Balance of nutrients to be supplied through concentrate mixture:

	DM (kg)	DCP (kg)	TDN (kg)
Total requirement	15.0	0.99	9.04
Green & Dry fodder	10.4	0.20	5.60
To be supplied through conc.	4.6	0.79	3.44

4. Amount of concentrate mixture required to meet the DCP requirement Amount of DCP to be supplied through concentrates = 0.79 kg Amount of DCP present in the concentrate mix = 16 %

- No. of kg of concentrate mixture = 0.79/16 x 100 = 4.9375 kg

5. Amount of TDN supplied through concentrate mixture Amount of TDN present in the concentrate mix = 70 % Amount of concentrate mixture to be offered = 4.9375 kg

- Amount of TDN supplied through conc. mix = 4.9375/100 x 70 = 3.456 kg

6. Verification:

Nutrients supplied Through	DM (kg)	DCP (kg)	TDN (kg)
NB – 21 green fodder	5.00	0.20	3.200
Paddy straw	5.40	0.00	2.400
Concentrate mixture	4.44	0.79	3.456
Total	14.84	0.99	9.056
Actual requirement	12.5 – 15.0	0.99	9.040

Skill Set (VETY) 34: Feed formulation for pigs

There is no single ration best for all types of pigs because the feed to be given depends on the stage of growth of pigs. The pigs ration can be either homemade or readymade which is purchased from the market.

The following aspect should be kept in mind while choosing the ration.

- The most economical ingredients should be selected.
- Grains like maize, sorghum, oats, other millets, wheat, and rice should form the basic ingredients.
- Protein supplements like oil cakes, legume grains, fish meal, and meat meal should be incorporated.
- Vitamins are added at the rate of 10 g/100 kg till the pigs are 2 months old. No vitamin supplement is necessary if the pigs are allowed to pasture or fed on fresh green legumes.
- Antibiotic supplements should be added at the rate of 10g per 100 kg of ration for pigs up to 2 months.

The most important components in pig feed from the quantity point of view are protein and carbohydrates. Of these, protein is the reference point of the ration. To begin with the proportion of the ingredients like fish meal, mineral mixture, common salt and vitamins should be fixed in every ration since only limited amount of these can be incorporated. Then rearranging the proportion of energy and protein feeds, the ration for all the categories of pigs can be calculated. The nutrient requirements of pigs are expressed as percent of the diet or the amount per kg ration (Appendix). The nutrient requirements for pigs have been group as follows.

i) For the period up to weaning (56 days of age)

ii) Growing period (2-4 months)

iii) Finishing period (5-6 months)

Computation of ration:

The swine diets are based on sources of energy and a protein supplement. Maize is the key energy feed in the swine industry as it is rich in energy. However, its cost and availability may pose a problem. Maize can be replaced at least in part by barley, oat, pearl millet, grain by-products or grain

substitutes. Groundnut cake alone will not meet the amino acid requirement of pigs and as such fish meal is also used at a level not higher than 5- 30 % due to high cost.

Example: Computation of 100 kg grower ration with the following ingredients: maize, groundnut cake, deoiled rice bran (DORB), and fish meal.

STEP 1. Nutrient requirement of grower ration (as per BIS,1986); CP= 18% and ME=3170 kcal/kg diet (on DM basis) or 16 % CP and 2850 kcal ME/ kg on 89 basis.

STEP 2. Keep slack space of 2.5 kg.

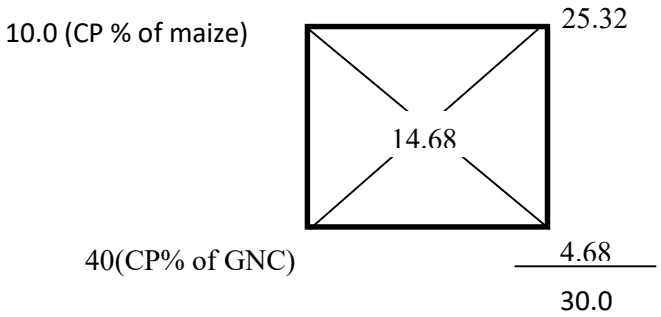
STEP 3. Fix the level of animal protein source. These ingredients provide the limiting amino acids like lysine, cystine and methionine. Fish meal = 6 kg

STEP 4. Fix the level of DORB @ 20 %.

STEP 5. Vegetable protein sources and energy sources are to be added to provide balance amount of protein. Till now 28.5 kg of ingredients were added (including slack space) and these contributed 5.50 percent protein. Still, 71.5 kg of ingredients are to be added to provide 10.5 % protein.

STEP 6. Calculate the percent protein needed from 71.5 kg (100-28.5) of the diet (10.5 /71.5) X 100= 14.68%

STEP 7. Calculate the percentage ingredients to be added in the final diet to provide 10.5% CP. This can be calculated by Pearson's square method. The central value should be 14.68 % CP as the total quantity of major ingredients available with us is 71.5 kg.



Amount of GNC to be used = (4.68/30.00) X 71.5= 11.15 kg

Amount of Maize to be used = (25.32/30.00) X 71.5= 60.34 kg

Therefore, the grower ration of 100 kg may contain the ingredients in the following proportion.

Ingredients	Amount (kg)	CP %	ME (kcal/kg)
Maize	60.34	6.03	1991.22
DORB	20.00	2.80	440.00
Ground nut cake	11.15	4.46	301.05
Fish meal	6.00	2.70	132.00
Limestone powder	1.50	-	-
Trace mineral mixture	0.45	-	-

Common salt	0.5	-	-
Vitamin A & D	0.25	-	-
Vitamin B complex	0.25	-	-
Total	100	15.99	2864.27

Skill Set (VETY) 35: Measurement of heart rate, pulse and ecg

Measurement of heart rate:

Different methods of measuring heart rate are known, namely: feeling the pulse, listening to heart tones, electrocardiogram, and telemeter methods. The most common method is the auscultatory method using a stethoscope. Measuring heart rate using a stethoscope involves listening to the heartbeats and counting them.

Apparatus requirement:

- Stethoscope
- Watch or clock with a second hand or a digital timer

Procedure:

- Prepare the animals: Ensure the animal is relaxed and has been at rest for at least five minutes.
- Place the diaphragm of the stethoscope on the animal's chest, specifically over the heart.
- Listen to the heartbeats: Ensure you have a good seal with the earpieces of the stethoscope in your ears. Listen for the "lub-dub" sounds of the heartbeat, which correspond to the closing of the heart valves.
- Count the heartbeats: Count the beats for 30 seconds and then multiply by 2 to get the beats per minute (bpm). Alternatively, count for 60 seconds for a more accurate measurement.

Note: If the rhythm is irregular, it is better to count for the full 60 seconds to get an accurate heart rate.

Recording of Pulse Rate:

A number of rises and falls of arterial wall i.e. beats are to be recorded for a specific period and calculated it in a minute. The beats can easily be felt at some specific site of various animals.

Sites for taking a pulse:

Animals	Site
Horse, Donkey, Mule	External maxillary artery
Cattle, Buffalo, pig and Yak	Middle coccygeal artery
Sheep, Goat, Calf	Femoral artery
Piglet, Dog and Cat	Femoral artery
Human	Carotid or Cephalic artery

Procedure:

- Hold the tail / limb in restraint condition

- Locate the artery for recording pulse accordingly
- Place the tip of the index / middle finger on the artery
- Count the pulse for one minute and record it

Record of Electrocardiogram

The electrocardiogram is the voltage–time graph of the electrical activities of the heart. It is record from beat to beat in some specific ways and helps in the diagnosis of many cardiac diseases. As the depolarization wave, also commonly called the cardiac impulse passes through the heart electrical current spread out from heart to the surface of the body.

Principle

The electrical activities of the heart can be picked up and recorded by placing electrodes on the skin at any part of the body. This is because the fluid with various electrolytes behaves as a volume conductor through which the effects of the cardiac electrical activities can spread its influence (body) and the activity is recorded from any part of the conductor.

Einthoven's triangle:

It is an Imaginary triangle joining right shoulder, left shoulder and middle of the inguinal region. It is an equilateral triangle with the heart at the centre. According to Einthoven's law, the algebraic summation of the voltage fluctuations in lead – I and that lead – III together equals voltage fluctuations in lead – II.

Materials required:

Electrocardiogram machine, Lead wires, Electrodes and Electrode gel.

Procedure:

- The subject is to be laid down on a non-conducting bed.
- It may be kept at stand still comfortable condition, particularly in case of domestic animal.
- Different lead connections are made to above mentioned to above mentioned parts of the body.
- Before recording the electrocardiogram, the machine should be checked by supplying 1mV voltage.
- The position of the stylus is to be placed properly by adjusting knob.
- Run the machine without any lead connection for final checking.
- The master knob is placed at different lead positions in the electrocardiogram machine for recording at different lead positions.
- The whole paper is taken out and the tracings are to be marked for further studies.

Precautions:

The subject must be kept in a resting and comfortable condition. Any metallic or conducting object, it remained, should be removed from body. Stylus position and deflection after connection carefully noted before recording. The master knob should be placed at the test position while changing the position of the chest lead.

COMMUNITY SCIENCE

FAMILY RESOURCE MANAGEMENT

Skill Set (FRM) 1: Use of hand grip dynamometer

Skills to impart: Use of hand grip dynamometer, hand strength technical know-how of taking readings.

Tools and materials: i) Hand Grip Dynamometer, ii) Chair, iii) Notebook and pen to record readings.

Hand Grip Dynamometer is a tool to measure the isometric strength of the hand and forearm muscles. It determines the hand strength of the individual. Handle material, handle length, handle shape, handle orientation, handle flange, handle grip span, grip method, tool weight, tool sharpness, as well as vibration exposure have significant effects on the hand grip strength. Therefore, the data generated is useful for designing user-friendly handheld tools.

- Explain the procedure to the subject.
- Ensure that the dynamometer handle is cleaned before use.
- Ask the subject to remove their shoes and also watch or bracelets
- Allow the subject to sit freely on a chair with a back support and fixed armrests.
- Allow to subject to rest the forearm on the armrest and check that the feet remain flat to the floor.
- Monitor that the subject does not raise the feet from the floor when squeezing the dynamometer.
- Ensure that the wrist should be just over the end of the chair's arm, thumb facing upwards.
- Allow the subject to hold their arm with the elbow bent at a 90-degree angle.
- Make the subject hold the hand grip dynamometer.
- Press the 'on' button and make sure that the dynamometer is sat to 'zero'.
- Allow the subject to squeeze the dynamometer for 3seconds and release.
- Press the 'on' button at the end of each reading. Ensure that the dynamometer is set to 'zero'
- Start with right hand and repeat the same with the left hand. Take readings alternately.
- Repeat for three times/ take three readings.
- Press the 'off' button on completion of the test.
- The average of the three readings is the hand grip strength.

Skill set (FRM) 2: Body mass index study

Skills to impart: Calculation of body mass index (BMI) from height and weight.

Tools and materials: i) Anthropometer ii) Weighing Balance iii) Notebook and pen to record readings

BMI is calculated using the height and weight of the subject. BMI determines whether the weight is in healthy proportion to the height of the subject. Finding of BMI is useful in the selection of subjects to carry out an ergonomic intervention.

Measurement of height

- Explain the procedure to the subject.
- Fix the different parts of the anthropometer before starting to take the readings.
- Allow the subject to stand straight upright looking ahead on a flat surface without footware. The line of sight and chin must be parallel to the floor.
- Remove braids, headbands, or anything else tied to the head for accuracy in measurement.
- Bring the anthropometer to the nearest point of the standing subject.
- Slide the sliding Calliper of the anthropometer to the level of the head from the top.
- Record the reading.

Measurement of Weight

- Explain the procedure to the subject.
- Clean the dust and dirt from the surface of the weighing machine.
- Place the machine on a flat surface.
- Set the machine to 'zero' before allowing for used.
- Ask the subject to remove footwear, watches, bracelets, etc. for measurement accuracy.
- Wearing of Light clothing is to be encouraged for more accuracy.
- Allow the subject to stand on the machine straight upright looking ahead. The line of sight and chin must be parallel to the floor.
- Record the reading.

Calculation of BMI

The formula to calculate

$BMI = kg/ m^2$

Where kg is the weight in kilograms and m^2 is the height in meters squared.

Skill Set (FRM) 3: Physical fitness test

Skills to impart: Step tool method of physical fitness test.

Tools and materials: i) Step tool ergometer ii) Heart rate monitor iii) Notebook and pen to record readings.

The physical fitness test is done to determine the ability of the subject to perform muscular activity especially for ergonomic studies. It indicates the musculoskeletal strength, endurance and flexibility as well the cardiovascular fitness.

- Explain the procedure to the subject.
- Place the step tool ergometer on even surface. Avoid slippery floor.
- Make the subject to wear the transmitter in correct position on the chest and the wristwatch of the heart rate monitor on the wrist.
- Allow the subject to sit in a relaxed sitting position for 5minutes.
- The heart rate for every minute will be recorded for the resting period.

- Allow the subject to start stepping on the wooden step tool ergometer on four count rhythm for 5 minutes.
- Record the working heart rate while the subject performs the uniform stepping exercise at the rate of 30 steps/minute
- Allow the subject to sit comfortably on completion of the stepping exercise.
- Record the recovery heart rate every minute for the duration of 5 minutes.

Calculation of Physical Fitness Index

The formula to calculate PFI

PFI = Duration of Stepping/Sum of 1st three readings of recovery x 100

Skill Set (FRM) 4: Back and leg strength study

Skills to impart: Technical knowhow of using a back and leg dynamometer.

Tools and materials: i) Back and leg dynamometer, ii) notebook and pen to record readings

Back strength measurement determines the strength of the core muscles (back and leg).

- Explain the procedure to the subject.
- Ensure that the dynamometer handle is cleaned before use to avoid accident with slippery handle surface.
- Ask the subject to remove their shoes and also watch or bracelets
- Place the dynamometer over a flat surface for accuracy.
- Set the dynamometer to 'zero' by pressing the 'on' button.
- Allow the subject to stand upright on the base plate of the dynamometer with bare foot and arms resting by the side of the body.
- Allow the subject to bend the knee at 135 degrees.
- The handle should be at the height of the hand when the subject is standing in slightly bent position.
- Ensure that the chain length is in accordance with the height of the hand of the subject. If not adjust the chain length.
- Ask the subject to grasp the handle with both hands and the hands facing the body.
- Allow the subject to pull up exerting force until reaches the maximum.
- Monitor that the feet remain flat at the time of puling and the machine remain stable in its position.
- Record the reading displayed in the dial of the dynamometer.

Skill Set (FRM) 5: Interior decoration

Skills to impart: Ability to plan for enhancing the functional and decorative aspects of an interior.

Tools and materials: i) Measuring tape ii) paper iii) templates of furniture.

Procedure:

- Take measurements of the room and mark them out on a piece of paper.
- Place the furniture templates in order to find their ideal placement in the room, keeping

in mind how occupants and guest will move around the room.

- Identify the source of the best natural lighting in your room, either from doors or windows, in order to decide where to place additional artificial lighting.
- Always generate good idea to choose what objects, furniture or even floor coverings to plan the interior design around. The items selected should ideally be in the style which inspires the choice of décor (Naturalism, Modernism, periodic etc.)
- Decide on the colours to be used in the room. Choose any colour scheme.
- While choosing colour scheme, consider the aspect of the room, size and shape of the room, furniture, curtains, walls, floors and doors to create a harmonious finish.
- Always start colour with the walls whether it is wallpaper or paint or any other wall treatment.
- To make a room seem bigger opt for bright or light colour.
- Always contrast wall colour by painting ceiling with white to enhance the ambience.
- Consider the floor colour that contrast somewhat with the walls – tones of light and dark.
- Consider the flooring material based on the size and aspect of the room to achieve a spacious and bright look.
- Choose texture of the flooring material based on the purpose of the room to achieve feet comfort.
- Once the overall look of the room is created position the furniture's. Try with both formal and informal balance arrangements. Decide one which works best. Add the finishing touches using decorative accessories, without cluttering the space and keeping the colour balance.
- Prioritise on artificial lighting as it plays an important role in shaping the room in evening hours and creates a comfortable atmosphere. Try placing the lights in different areas of the room before final installation.
- Choose light fixtures considering its purpose whether for general, decorative or local lighting.
- Choose correct texture of the materials, illumination level is dependent on the surface quality of the object placed in the interior.
- Size of the pattern on the soft furnishings must go with the size of the room.

Skill Set (FRM) 6: Floor for different income groups

Skills to impart: Allocation of space for specific purpose in a residential building.

Tools and materials: i) Plain paper, ii) graph paper, iii) scale, iv) pencil and eraser

Floor plan allows to know the location of the rooms in a given floor area according to its purpose. It shows a general layout of the interior. Knowledge on allocation of space for rooms and proper positioning allows planning for a functional interior for LIG, MIG and HIG housing.

1st stage

- Orient the layout of the building considering the direction of the sun, wind and rain.
- Start positioning of the rooms with proper grouping with the help of bubble diagram on a plain paper. Use different shape of bubbles to represent the significance and size of each space.
- Group the rooms of a residential building based on functional relationship (Public Area, Service Area and Private area)
- Check that positioning of the rooms whether
    - Will provide adequate privacy to the inmates

- Proper utilization of the available space is done
- Independent access to all rooms is maintained
- Plan rooms of rectangular shape, it provides good space for arrangement of furniture and gives spaciousness than a square shape room

2nd Stage

- Indicate the path for circulation with the help of arrow in the bubble diagram to indicate the position of the doors in a building in the interior and exterior walls.
- Do not align the doors in the same alignment, it will affect privacy.
- Position the doors on the corner of the larger walls to allow maximum unexposed area inside the room.

3rd Stage

- Convert the bubbles to block. The blocks will give definite shape to the rooms.

These three stages help the owner to have an overview of the location of the rooms, the shape of the rooms, and entry and exit ways in the proposed building. Allows the planner to come out with functional floor plan.

4th Stage

Consider a scale (For e.g., 1cm as 1ft or 0.5cm as 1ft) to fit the large area in a piece of paper.

- Indicate the 'N' direction using the symbol 
- Use scale and architectural symbols to draw the exterior walls on graph paper. Consider the square feet area to draw the length and width of the layout.
- Draw the partition walls using the internal wall symbol to divide the total floor area into smaller units to meet the functional requirements of the family. Decide dimensions of the different units considering the activity/ies to be performed.
- Draw door swing to indicate the entry and exit at the front, rare and interior of the building
- Position the windows on the exterior walls considering the best aspect for different units of the building.
- Using furniture symbols, add major furnitures to the rooms such as the living, dining, bedroom, study room. This will indicate the free space for circulation within the room.
- Add appliances, fixtures and plumbing using symbols.
- Draw the electrical symbols in the floor considering the position of the fixtures and fitting on the ceiling.
- Mention the dimension of the rooms.
- Labelled the rooms.

Skill Set (FRM) 7: Floor plan for functional interiors

Skills to impart: Design considerations for functional interiors for special needs.

Tools and materials: i) Plain paper, ii) graph paper, iii) scale, iv) pencil and v) eraser

Developing a floor plan for functional interiors for special needs centred on space allowances.

- Consider a scale (For e.g., 1cm as 1ft or 0.5cm as 1ft) to fit the large area in a piece of paper.
- Indicate the 'N' direction using the symbol 
- Use scale and architectural symbol to draw the exterior walls on a graph paper. Consider the square feet area to draw the length and width of the layout.

- Draw the partition walls using internal wall symbol to divide the total floor area in to smaller units to meet the functional requirements of the family. Decide dimension of the different units considering the activity/ies to be performed.
- Draw door swing to indicate the entry and exit at the front, rare and interior of the building. Allow the door to swing inward.
- Position the windows on the exterior walls considering the best aspect for different units of the building.
- Using furniture symbols, add major furniture's to the rooms such as living, dining, bedroom, and study rooms. This will indicate the free space for circulation within the room.
- Add appliances, fixtures, and plumbing using symbols.
- Draw the electrical symbols on the floor considering the position of the fixtures and fitting on the ceiling.
- Mention the dimensions of the rooms.
- Labeled the rooms.

The following space allowances need to be considered while developing a floor plan for special needs (Wheelchair Users)

- Entrance door 1000mm door set
- Doors should swing beyond 90°
- Clear circulation space of 1500mm x 1500mm between projections for 360^0 turns of the person in wheelchair. To be considered while position bathroom fixtures and furniture's
- Between center of the toilet seat and the wall must a have a minimum distance of 500mm
- Clear space of 1000mm from center of the pan on the open side of toilet for proper maneuvering of the wheelchair user
- A minimum of 1200mm from the front of the pan to the nearest obstruction
- Free space of 900mm to be set between the bed and the wall for easy maneuvering

Skill Set (FRM) 8: Furnishings development

Skills to impart: Techniques to develop furnishing to suit the décor

Tools and materials: (i) Required soft and hard materials (ii) machine and kit (iii) pliers (iv) cutter.

Good decision for furnishings enhances the overall ambiance and satisfy the personal interest of the inmates while using the building. The following considerations will help in developing suitable furnishing for enhancing the ambiance while fulfilling the functional needs.

- Consider the elements of art applied in the interior settings- line, shape, form, colour, texture, light, and space.
- Consider the age of the occupant as the taste of the occupants differs with the change stages of the life cycle.
- Consider the purpose of the room, whether a living, dining, or bedroom.
- Consider the tastes/ideas of the occupants.
- Select soft material keeping in account the aspect of the room as some soft furnishing materials are energy efficient and can retain heat and make the room more warm.
- Select soft furnishings for upholstery furniture's with texture which provides a feeling for comfort on use.
- Select curtains and draperies that go with the upholstery material of the furniture's.
- Select sheer materials for curtains on windows.
- Choose colour and texture of the draperies considering the light level during the day time.
- Select cushions and throw pillows in seating areas to add more comfort and to break the monotony.

- Carpets and area rugs may be incorporated for sound insulation in areas where required. Also, can be placed near furniture arrangements to add harmony and foot comfort.
- Select materials for bed linens with anti-static properties and texture that provide comfort.
- Select materials for dining linens having high absorbency properties.

Skill Set (FRM) 9: Agarbatti making

Skills to impart: Technical knowhow of making hand rolled Agarbatti

Tools and materials: i) Carbon powder/black powder ii) gum powder/ brown powder iii) dhoop/ dhuna powder iv) bamboo sticks v) water vi) newspaper vii) bowl viii) fragrance oils ix) painting flat brush small

Procedure

- Spread the newspaper or any paper for spreading and drying the hand-rolled agarbatti.
- On the newspaper spread some dhuni powder or dhoop powder to avoid sticking.
- Take a bowl and add carbon powder/black powder according to your desired quantity. (Amount Provided in note)
- Add gum powder to the above and mix with your hand.
- Add dhuni powder/dhoop powder and mix it well all the ingredients.
- Add water to the above mixture and mix with your hand till it becomes smooth in consistency.
- The mixture paste should not be watery and very thick.
- The consistency should be such that the paste should stick to the bamboo sticks while making the agarbatti.
- After thorough mixing take a bamboo stick in your hand and take the paste (around 8 to 10 gm) and apply on the stick vertically leaving two to three inches.
- The size and shape of the agarbatti can be made accordingly while it is in a wet state.
- Roll the agarbatti on the dhoop powder which was already kept/ spread on the newspaper.
- Keep the agarbatti on the newspaper for partially drying.
- One by one make your desired quantity of agarbatti.
- After partial drying roll with your hand to make it smooth.
- After rolling keep drying in the sunlight.
- If desire, apply fragrance with the help of brush and seal in airtight container.

Note:

For Making 1 kg Agarbatti- 250 g Carbon powder/black powder, 120 g Gum powder/brown powder, 20 g Dhoop powder, 600 Bamboo sticks, water 150 ml

Skill Set (FRM) 10: Mosquito repellent incense stick making.

Skills to impart: Technical knowhow of making mosquito repellent incense stick making.

Tools and materials: i) Carbon powder/black powder ii) gum powder/ brown powder iii) Dhoop/ dhuna powder iv) citronella extract (powder) v) citronella oil vi) bamboo sticks vii) water viii) newspaper ix) bowl x) fragrance oils xi) painting flat brush small

Procedure

- Take a bowl and add carbon powder/black powder according to your desired quantity. (Amount Provided in note)
- Add gum powder to the above and mix with your hand.
- Add *Citronella* powder and dhuni powder/dhoop powder and mix it well again.
- Add water to the above mixture and mix together with your hand till it becomes smooth in consistency.
- The mixture paste should not be watery and very thick.
- The consistency should be such that paste should stick to the bamboo sticks while making the incense stick.
- After thorough mixing take a bamboo stick in your hand and take the paste (around 10 to 12 gm) and apply on the stick vertically leaving two to three inches.
- The size and shape of the incense stick can be made accordingly while it is in the wet state.
- On the newspaper spread some dhoop powder or citronella powder roll the incense stick and keep it for drying.
- After complete drying apply citronella oil with the help of a paint brush.

Note:

For Making 1 kg mosquito repellent incense sticks- 200 g Carbon powder/black powder, 100 g Gum powder/brown powder, 100 g citronella powder, 20 g Dhoop powder, 600 Bamboo sticks, water 150 ml

Skill Set (FRM) 11: Designing of interior accessories.

Skills to impart: Technical knowhow of making flowers from areca leaf sheath (Agro Waste)

Tools and materials: i) Arecanut leaf sheath, ii) bamboo sticks or aluminium wire iii) thread iv) green tape v) glue/ fevi quick vi) varnish (if desired) vii) paint brush for applying varnish viii) bowl ix) scissors and knife x) water xi) hair straightening machine.

Accessories are the elements or products that add beauty, charm, and individuality to a room. They complete the decorative aspects of a room and make the interior attractive. Flowers are commonly used as interior accessories and dehydrated eco-friendly flowers are becoming more common which also gives an aesthetic look.

- Clean or wash the arecanut leaf sheath properly to remove any blemishes or dirt.
- Soak the arecanut leaf sheath in a vessel of water for 1- 2 hours.
- Cut into desired patterns or shapes for making flower petals.
- Remove the upper and lower layers with the help of a knife/hand.
- Let it dry for some time, while drying make a curl shape or one can use a hair straightening machine to give a curl look.
- For making the stamen, cut the soaked arecanut leaf bark into stamen-like shape from the upper portion. Let stamens be from one piece so that it can be easily inserted on a twig/ bamboo stick or aluminium wire
- Tie the stamen from the lower portion with the help of a thread or glue.
- Take the petals one by one and tie them around the stamen to make a flower.
- After complete drying, one can apply varnish to give a glossy finish.

Note: Similarly, Agro waste such as corn cover, dried sponge gourd, pine cone, etc. Can be used a main raw material for making flower

Skill Set (FRM) 12: Floor decoration of Indian culture

Skills to impart: Technical knowhow of making rangoli, floor decoration of Indian culture.

Tools and materials: i) Coloured saw dust powder or rangoli powder, ii) flower petals and leaves, iii) accessories such as diya or statue iv) pencil/chalk vi) scale.

Floor decoration is not just a decoration but has spiritual meanings. Most of the state in India practices some form of floor decoration or art during cultural ceremonies. It signifies the welcoming of God and Goddess to have the blessing in the auspicious occasion. Different themes, styles, and motifs are linked with each variation of Indian floor art. Rangoli, a floor decoration is mainly done by Hindu households during Diwali festivals.

- Choose the design of your choice or according to the occasion or theme of the cultural festival.
- Draw the design outline on the floor with the help of a pencil or chalk.
- If any straight line is to be drawn, you may use a scale.
- Fill the design with the powder colour according to the appropriate colour combination.
- Place the flower and petals according to the design of the rangoli.
- Also, light the diya or place a statue of God/Goddess to give an aesthetic look to the ambiance.

Note: Rangoli can be made in a wide variety of designs, sizes, and materials. Material such as rice powder, atta, grains, pulses, mud, sand, and brick powder are used for making floor decorations in India traditionally. Floor decoration has different names in India, namely Alpana in West Bengal, Aripan in Bihar, Kolam in Tamil Nadu, Mandala in Rajasthan, Mugulu in Andhra Pradesh etc.

TEXTILE AND APPAREL DESIGNING (TAD)

Skill Set (TAD) 1: Skill of weaving

Skills to impart: Preparatory preparation warping and process of weaving on loom.

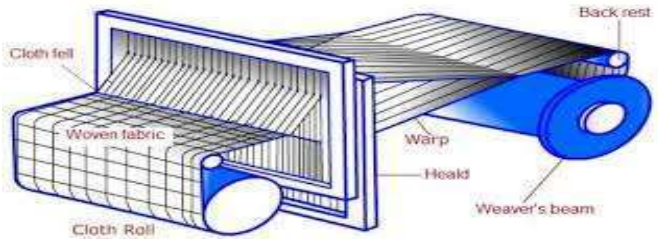
Tools and materials: Shuttle fly loom, Natural yarn (cotton, wool, silk), synthetic yarn (polyester, nylon), blends as per end uses, Boat shuttles, bobbins, Heddles, harness frame, Reeds, Warping boards, Scissors, Measuring Tools (rulers, tape measures, gauges, etc.)

A. Warp Preparation

- Select the yarn based on the desired texture, strength, and appearance of the finished textile. Warp yarns should be sized with a starch to provide the necessary strength and tension during the weaving process.
- Warping the Loom- Measure and cut the warp threads to the required length. Warp the loom by threading each warp thread through the heddles and reed, ensuring even tension and alignment.
- Tie the warp threads securely to the front and back beams of the loom, maintaining consistent tension across all threads.

B. Weft Preparation

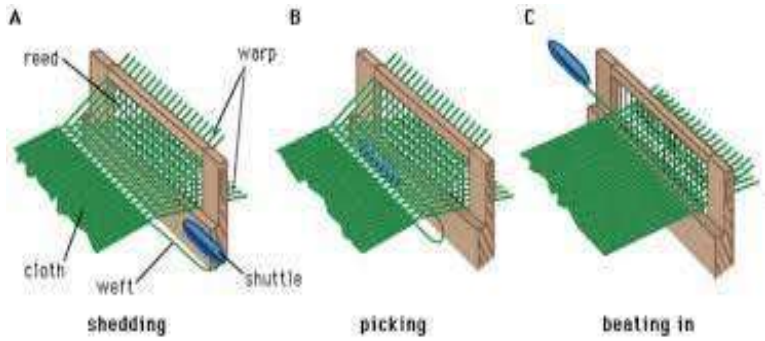
- Select a weft yarn that complements the warp yarn in texture, colour and strength.
- Wind the weft yarn onto shuttles or bobbins, ensuring it is free of knots and tangles.



- Determine the pattern or design for the weaving, deciding how the weft will interlace with the warp.

C. Weaving Process

- Use the heddles to raise and lower the warp threads, creating a space (shed) for the weft to pass through.
- Pass the shuttle carrying the weft yarn through the shed, weaving it over and under the warp threads.
- Use the reed to press (beat) the weft yarn into place, ensuring it is tight and even.



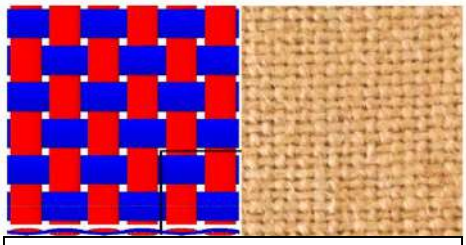
- Once a section is woven, advance the warp to create more space for weaving by rolling the fabric onto the front beam and releasing more warp from the back beam.

Pattern Weaving

Basic Weaves: Practice fundamental patterns like plain weave, twill, and satin, understanding their structures and applications.

Complex Patterns: Explore more intricate designs such as herringbone, basket weave, and damask, using multiple heddles and treadles.

Color and Texture Variations: Experiment with different weft yarns, colors, and textures to create visually and texturally interesting fabrics.



Weave Patterns (Plain and Twill weave)

D. Finishing the Fabric

- Once the desired length is woven, secure the end of the fabric by tying or stitching the final weft threads.
- Carefully cut the fabric from the loom, leaving sufficient warp ends for finishing.
- Hem, fringe, or otherwise finish the edges of the fabric to prevent unravelling.
- Wash and press the fabric to set the weave and enhance its appearance and feel.

Skill Set (TAD) 2: Skill of fashion illustration and sketching techniques

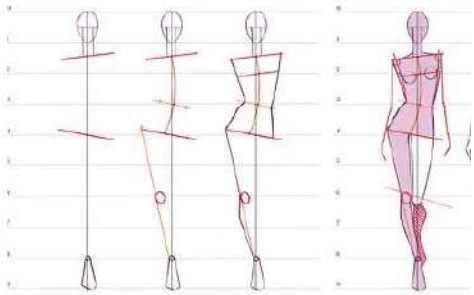
Skills to impart: Basic drawing skills (line quality, shading, proportion, colour rendering, Sketching different body poses and movements accurately to adapt figure proportions for different body types and fashion styles, Illustrate fabric textures and patterns, colours including harmonies, contrasts, and the emotional impact of colours, Skills in illustrating fashion accessories such as shoes, bags, jewellery, and hats, Proficiency in using digital tools and software for fashion illustration, Skill to curate and present a professional design portfolio.

Tools and materials: Drawing supplies (pencils, erasers, markers and pens, colored pencils and watercolors, blending brushes, sketchbooks and drawing sheets, tracing paper, digital tools (graphics tablets like iPad), software (Adobe Illustrator, Photoshop, Procreate), computer or laptop

Fashion illustration and sketching techniques involve imparting a blend of technical skills and creative expression. Mastery of basic drawing, understanding of fashion figure proportions, and proficiency in garment and accessory rendering is essential for a fashion designer to convey their design ideas effectively. With the right tools and materials, coupled with structured procedural steps, designers/students can develop their abilities to create compelling and professional fashion illustrations. This foundation is crucial for their growth as designers and their ability to thrive in the dynamic world of fashion.

1. **Basic Drawing Techniques**

- Start with simple exercises in drawing lines, shapes, and shading to build foundational skills.
- Progress to sketching basic human anatomy with emphasis on the proportions of fashion figures.
- Introduce dynamic poses and movements to enhance the realism and expressiveness of sketches.



2. Fashion Figure Drawing

- Use the standard proportions templates used in fashion illustration, and learn the standard proportions of fashion figures and how to construct them step-by-step.
- Practice drawing the skeletal framework and adding muscle contours to build realistic figures.
- Draw different body shapes and sizes to reflect diversity in fashion.
- Practice sketching figures in static and dynamic poses.

3. Garment Rendering Techniques

- Begin with basic garment shapes like skirts, tops, and dresses and gradually introduce more complex designs.
- Use fabric swatches and reference images to practice rendering different textures and patterns.
- Draw intricate details and how they interact with the garment's structure, considering fit, drape, and movement.

4. **Colour and Texture Application**

- Use various colour theory and colouring techniques using various mediums like markers, water colour, or digital tools.
- Create colour palettes that complement the design and convey the intended mood.
- Practice applying colour to sketches, focusing on creating cohesive and visually appealing palettes.
- Develop personalized colour palettes through mood board for different design concepts.
- Use various techniques for rendering different fabric textures and patterns realistically.

5. **Fashion Accessories Designing**

- Draw accessories into the overall look and enhance the design.
- Sketch different styling elements, including hair, makeup, and overall outfit coordination.
- Draw basic shapes and structures of common fashion accessories.
- Practice integrating accessories into complete outfits, considering balance and proportion.
- Explore different styling techniques and how they contribute to Fashion illustration.

6. Digital Illustration Techniques

- Use basic digital drawing tools and software such as Adobe Illustrator, Photoshop, or Procreate.
- Conduct exercises to translate traditional sketching skills into digital formats.
- Create digital templates, using layers, and applying effects in digital painting using digital illustration software and basic digital drawing tools.
- Conduct exercises that transition from hand-drawn sketches to digital rendering.
- Apply digital effects to enhance the realism and detail of illustrations.

7. Portfolio Development

- Select the best works and organize them into a cohesive portfolio.
- Create visually appealing layouts.
- Provide feedback on the layout to enhance the portfolio's professional appeal.
- Include diverse works that showcase a range of skills and styles.

Skill Set (TAD) 3: Skill of handicraft making utilizing natural fibers

Skills to impart: Knowledge of various natural fibers like banana, bamboo, cane, jute, and coconut fibers, including their properties and uses, skills in preparing and processing raw fibers for craft-making, such as fiber extraction, scouring, bleaching and softening techniques, proficiency in coiling, knotting, plaiting, and other techniques to create fiber craft.

Tools and materials: Cutting tools (scissors, knives, and shears), large-eye needles, crochet hooks, and bodkins for stitching and pulling fibers, splitting tools (splitters and shredders for preparing bamboo, cane, or banana fibers), matting needles (for preparing mats or rugs from fibers), braiding boards and spindles, Natural Fibers (Banana, bamboo, cane, jute, coconut husk and other natural fibers suitable for crafting), Natural dyes and mordants for colouring fibers thread, cord, beads, buttons, dyes, and paints for embellishing fibres products, Varnishes to protect and enhance the durability of the crafts

Handicraft making with natural fibers such as banana, bamboo, and cane is a traditional art that blends creativity with sustainable practices. These materials are versatile, eco-friendly, and offer unique textures and aesthetics, making them ideal for crafting a variety of products from baskets and mats to decorative items and accessories. This skill set not only fosters artistic expression and sustainability but also opens up opportunities for entrepreneurial ventures in the handcrafted goods market.

1. **Material Selection and Preparation**
    - Select appropriate natural fibers based on the desired characteristics of the finished product (e.g., flexibility, strength, texture).
    - Scour and bleach the fibers to eliminate dirt or impurities, following the standard procedure for cellulosic fibers. Immerse the fibers in a solution of mild detergent and warm water to remove dirt, dust, and natural oils. Gently agitate the fibers to ensure thorough cleaning.
    - If needed, soak or steam the fibers to soften them, facilitating easier manipulation and handling.
    - Split and strip fibers like bamboo or cane into strips for craft making.

2. **Design Planning**
   - Conceptualize and develop a clear idea of the desired product. Sketch the design and plan the dimensions, structure, and decorative elements.
   - If the product requires precise measurements, create patterns or templates to guide the crafting process.
3. **Crafting the Item using various techniques**
   - Use Coiling, Braiding and Knotting techniques for shaping the fiber craft. For coiling, braided or knotted designs, prepare the fibers by cutting them to the required length and proceed with the braiding or knotting process.
   - Use appropriate techniques to join and bind parts of the product, such as sewing or tying with twine or thread.
   - Various kind of bags, purses, bins, baskets and artisan products can be prepared by utilizing above techniques.



4. **Finishing of products**
   - Apply natural dyes, paints, or varnishes to the crafted item to enhance its appearance and durability.
   - Add any decorative elements like beads, buttons, or embroidered details to embellish the products.
   - Clean the finished product to remove any loose fibers or debris. Polish if necessary to achieve a smooth finish.
5. **Quality Check**
   - Inspect the product for quality check before launching in the market. Check the finished product for any defects or areas that need improvement.
   - Ensure that all joins and bindings are secure, and the overall appearance meets the design criteria.
   - Prepare a product catalogue for future orders.
   - Create a brand identity that reflects the uniqueness and sustainability of the handcrafted products.
   - Use online platforms, social media, and local markets to promote and sell the products. Highlight the use of natural fibers and eco-friendly practices.

Skill Set (TAD) 4: Skill of agro-based fiber extraction and value addition

Skills to impart: Understanding the types of agro-waste suitable for fiber extraction and diversified product development, proficiency in mechanical, chemical, and biological processes for extracting fibers from different agro-based sources, skills in refining extracted fibers to enhance their quality, including bleaching,

softening, and dyeing, knowledge of transforming raw fibers into value-added products such as yarns, fabrics, composites, and craft items.

Tools and materials: Retting Tanks for fiber separation, Decorticating Machine (Mechanical devices for stripping and separating fibers from husks or stems, combing tools for aligning and cleaning fibers after extraction. Natural Dyes and softening agents, Spinning and Weaving Tools- Spindles, spinning wheels, and looms for converting fibers into yarns and fabrics.

The extraction of fibers from agricultural byproducts such as arecanut husks, banana stems, and bamboo offers sustainable alternatives to synthetic materials and opens up various entrepreneurial opportunities. Developing skills in agro-based fiber extraction and value addition not only promotes sustainable practices but also opens up numerous entrepreneurial opportunities.

1. Selection of suitable material

- Choose agro-waste materials like arecanut husks, banana stems, or bamboo that are known for their fiber content.
- Carefully harvest the raw materials, ensuring minimal damage to retain fiber quality. For example, collect mature arecanut husks or banana stems post-harvest.

2. Pre-preparation and Fiber Extraction

- Scour the fiber and remove any dirt or impurities from the raw materials.
- Soak the materials in water (natural retting) or use controlled microbial or chemical retting to loosen the fibers. This process can take several days to weeks, depending on the material and method used.
- Use decorticating machines or manual tools to strip and separate the fibers from the retted material.
- Comb or align and clean the fibers to prepare them for further processing or direct use. This may involve combing or carding to remove any remaining impurities and ensure uniformity.

3. Drying and Softening

- Dry the extracted fibers thoroughly in natural sunlight or drying chambers to prevent mold and ensure durability.
- Treat the fibers with softening agents or bleach as needed to enhance their quality and prepare them for value-added applications.

4. Value Addition and diverse product development

- Convert the refined fibers into yarns or weave them into fabrics using spinning wheels and looms.
- Develop innovative products like eco-friendly bags, mats, or composite materials by combining fibers with other sustainable elements.
- Package the finished products attractively and sustainably, ready for market presentation.

Skill Set (TAD) 5: Skill of recycling and upcycling of textile waste

Skills to impart: Skill in generating innovative ideas for transforming textile waste into new products, strategies for minimizing textile waste and maximizing material

utilization, and developing a range of marketable products using recycled textiles.

Tools and materials: Textile Waste (Scraps, discarded garments, old linens, curtains, etc.), Scissors, rotary cutters, sewing machines, needles, threads, dyeing equipment, printing screens, heat press, Embroidery machines, appliqué tools, decorative trims, zippers, buttons, yarn for embellishments.

By imparting skills in recycling and upcycling textile waste, individuals can contribute to reducing environmental impact while creating unique and sustainable products. Through creativity, technical proficiency, and a commitment to sustainability, artisans, and designers can transform textile waste into valuable commodities, promoting a circular economy and inspiring others to adopt eco-friendly practices in their projects and businesses.

1. Collection and Sorting

- Collect textile waste from sources such as manufacturing scraps, discarded garments, or donated textiles.
- Sort textiles by type, colour, and condition to determine suitability for recycling or upcycling.

2. Cleaning and Preparation

- Wash and clean textiles to remove dirt, stains, and odours.
- Disassemble garments or larger items to separate usable fabric pieces from zippers, buttons, and other components.

3. Design and Planning

- Conceptualize and brainstorm ideas for new products based on available textile materials.
- Create sketches and prototypes to visualize and refine designs.

4. Material Processing

- Cut textile pieces into desired shapes and sizes.
- Join with appropriate seam pieces together using sewing machines or hand stitching to assemble into new products.

5. Embellishment and Finishing

- Renew the colour and appearance of recycled material by applying dyes or printing techniques.
- Add embellishments such as embroidery, appliqué, or decorative stitching to enhance recycled products.
- Complete final assembly of products, ensuring seams are secure and finishes are neat.
- Inspect finished products for quality, durability, and aesthetic appeal.
- Package products using eco-friendly materials and labels indicating their recycled or upcycled origins.

Skill Set (TAD) 6: Skill in garment construction and accessories designing

Skills to impart: Understanding of basic garment patterns and the ability to create custom patterns, skills in measuring, drafting, and adjusting patterns to fit specific body measurements and design requirements, ability to modify and adjust patterns for custom fitting and various design alterations, knowledge of assembling garments, including seam finishing, dart manipulation

Tools and materials: Pattern-making and drafting tools-pattern paper, tape measures, French curves, and straight rulers, fashion fabric, lining, underlining, interfacing material, zippers, buttons, hooks, elastics, and other closures and fasteners, cutting and marking tools-fabric scissors and rotary cutters, chalk, fabric pens, and tailor's chalk, sewing tool-sewing machines, bobbins, needles, and thread, hand sewing needles, pins, seam rippers, threads, irons and steamers, beads, sequins, ribbons, and appliqués for embellishments,

Garment construction and accessories designing are fundamental skills in the fashion industry, offering a blend of creativity and technical expertise. Mastery in these areas enables individuals to create a wide range of apparel and fashion accessories, paving the way for careers in fashion design, tailoring, and entrepreneurship.

1**. Design Concept and Planning**

- Collect ideas and inspiration from fashion trends, history, and personal creativity.
- Create initial sketches and illustrations of the garment or accessory design.
- Choose appropriate fabrics and materials based on the design requirements and intended use.

2. Pattern Making and Drafting and cutting

- Draft patterns based on measurements or design specifications. Use pattern paper and drafting tools to create templates for each piece of the garment or accessory.
- Prepare basic pattern blocks (bodice, skirt, trousers) and modify them for different designs.
- Lay out the pattern pieces on the fabric, ensuring correct grain alignment, and cut the pieces accurately.

3. Construction and Assembly

Sewing Garments

- Sew the fabric pieces together, following the pattern instructions. Use appropriate seam finishes to ensure durability.
- Fitting Adjustments to make any necessary adjustments to ensure a perfect fit.
- Add details such as pockets, collars, cuffs, and fastenings.

Crafting Accessories

- Use hand tools and sewing techniques to assemble the components of the accessory.
- Apply decorative elements to enhance the appearance of the accessory.

4. Finishing and Quality Control

- Press seams and hems to ensure a polished look. Finish raw edges and apply any final touches.
- Check for any construction flaws or inconsistencies and make necessary corrections.
- Attach labels, tags, and any branding elements to the product.

Skill Set (TAD) 7: **Skill of organizing fashion shows and pop-up events**

Skills to impart: Skill of generating themes and concepts for the fashion show or pop-up event, skill of directing model casting, fittings, rehearsals, and choreography, Skill of selecting and styling fashion collections to align with the event theme, creating appealing displays for pop-up events to showcase products effectively.

Tools and materials: Event space or runway venue, stage platforms, runway lights, spotlights, and sound equipment, seating arrangements, tables, display stands for pop-up events, event signage, and digital content, flyers, posters, banners, display racks, shelving units, and signage for pop-up events backdrops, cameras, projectors, and screens for recording and displaying the event.

Organizing fashion shows, runway events, and pop-up shows requires a blend of creativity and organizational skills. By imparting these skills, individuals can successfully plan, coordinate, and execute fashion events that showcase creativity, innovation, and style. Whether aiming to launch new collections, promote sustainable fashion, or celebrate cultural diversity, mastering the art of event organization ensures an impactful experience for participants.

1. Conceptualization and Planning

- Finalize a theme or concept for the fashion show or pop-up event that aligns with the brand or collection being showcased.
- Prepare a budget and timeline outlining tasks, deadlines, and responsibilities.
- Research and select a suitable venue that complements the event theme and accommodates audience.
- Plan stage setups, seating arrangements, and backstage areas.
- Coordinate with fashion designers to showcase their collections.
- Distribute press releases and attract media coverage to generate buzz around the event.

2. Event Execution

- Conduct model fittings, rehearsals, and run-throughs to ensure smooth execution on event day.
- Coordinate lighting, sound, and stage effects for optimal presentation.
- Manage attendee arrivals, registration, and seating arrangements.
- Runway Management- Direct models, manage backstage operations, and oversee the flow of the fashion presentation, show timing and transition.

3. Post-Event Activities

- Gather feedback from attendees, participants, and stakeholders to evaluate event success.
- Debrief with team members, review event outcomes, and identify areas for improvement.

Skill Set (TAD) 8: Skill of natural dyeing

Skills to impart: Knowledge about natural dye sources and mordants, dye extraction techniques and mordanting techniques, techniques such as tie-dyeing, shibori, and batik for creating patterns on fabrics.

Tools and materials: Plant based natural dye sources, natural mordants, natural dyeing material, stainless steel, enamel, or ceramic pots for boiling and dyeing fabrics, non-

reactive spoons or sticks for stirring dye baths, strainers and sieve, measuring cups, and spoons, gloves, aprons, mild soaps/ detergents, drying racks

Natural dyeing is a traditional craft that uses plant, animal, and mineral sources to color textiles. This eco-friendly and sustainable method of dyeing offers vibrant and varied hues while minimizing environmental impact. By imparting knowledge of dye sources, extraction techniques, and application methods, individuals can create beautiful and eco-friendly textiles. Through hands-on practice and an understanding of natural materials, learners can transform raw textiles into vibrant works of art and viable commercial products, contributing to the growing demand for sustainable fashion and home goods.

1. Pre- Preparation

- Select natural fabrics that are well-suited to absorb natural dyes or end application.
- Soak overnight and thoroughly wash the fabric to remove any sizing or finishes that could interfere with dye uptake.
- Collect and prepare natural dye materials. For plant-based dyes, this often involves chopping or grinding the plant parts.

2. Extraction of Dyes and Mordanting

- Boil the dye materials in water to extract the pigment. The extraction time varies depending on the material, usually ranging from 30 minutes to 1 hr.
- For certain dyes like indigo, fermentation is used to extract the dye in a more complex process involving fermentation vats.
- Dissolve the mordant in water according to the type of fabric and desired effect. Alum is commonly used for bright colours, while iron can create darker hues.
- Immerse the fabric in the mordant solution and simmer gently to ensure even uptake. The fabric is typically mordanted for 30-60 minutes, then rinsed and dried.

3. Dyeing Process

- Immersion Dyeing- Strain the extracted dye liquid and heat it in a dye pot.
- Submerge the mordanted fabric in the dye bath and simmer gently. Stir occasionally to ensure even dyeing. The duration can vary from 30 minutes to 1 hour.
- Surface Dyeing- Tie-Dyeing/Shibori- Fold, tie, or stitch the fabric to create resist patterns. Submerge or apply dye selectively to achieve desired patterns.
- Batik- Apply wax to areas of the fabric to resist dye penetration. After dyeing, remove the wax to reveal the pattern.

4. Rinsing and Finishing

- Rinse the dyed fabric in cold water until the water runs clear, removing excess dye.
- Some natural dyes may require additional steps, like a final soak in a salt or vinegar solution, to fix the colour followed by steaming.
- Air-dry the fabric, avoiding direct sunlight to prevent colour fading.

5. Post-Dyeing Treatment

- Inspect the dyed fabric for colour uniformity and desired shade.
- Consider adding further embellishments like embroidery or appliqué.
- Plan and create products using the dyed fabrics, such as apparel, home decor, or art pieces.

HUMAN DEVELOPMENT AND FAMILY STUDIES

Skill Set (HDFS) 1: Early childhood care and education

Activity name: Counting with Nature/ Nature Walk

Skills to impart: Planning and conducting a play-based mathematics curriculum for preschoolers.

Tools and materials: Collect leaves, stones, and sticks.

Procedure:

1. Take a nature walk outside with the children and ask children to collect natural items
2. Back in the classroom, count the items together.
3. Arrange them in groups (e.g., all leaves together) and count each group.

Learning Outcome: Understand numbers and practice counting that will improve physical health, motor skills, curiosity and exploration, enhance creativity and imagination as well as increased attention span and communication skills

Activity 2: Sorting and Classification

Tools and materials required: Various objects (buttons, blocks, toys) of different sizes, colors, and shapes.

Procedure:

1. Provide bins or trays for sorting.
2. Encourage children to sort objects by color, size, or shape.

Learning outcome: Develop sorting and classifying skills.

Activity 3: Counting games

Materials required: Litchi seeds and stone chips, 5 empty bowls

Procedure:

1. Place litchi seeds and stone chips in one corner of the play area.
2. Provide each child with an empty bowl.
3. Instruct the children to collect the seeds or stones and fill their respective bowls and reportthe number of seeds and stones to the teacher.
4. Enhance the excitement by beating a drum when the game starts and continue until the lastchild finishes.
5. The teacher verifies the count, and if correct, the child is declared the winner.
6. The child who completes the task first with the correct number of stones or seeds is declaredthe first.
7. Incorrect counts result in a time penalty.

Learning outcome: This game reinforces counting skills and encourages teamwork and communication.

Skill Set (HDFS) 2: Storeytelling and dramatization method for preschoolers

Materials Required: Posters or flash charts with images representing key scenes of the story, Props or simple costumes (optional, but helpful for dramatization), A designated storytelling area (e.g., a rug or circle area).

Procedure:

1, Choose a simple, engaging story suitable for preschoolers.

2. Create or gather posters or flash charts that illustrate key scenes of the story
3. Prepare any props or custumes if available
4. Gather the children in the storytelling area
5. Introduce the story by showing the cover of the book or a title poster. Briefly explain what the story is about to capture their interest.
6. Use of visual aids
7. Use of gestures and facial
8. Use of different sounds and voice modulation
9. Ask occasional questions to keep the children engaged. For example, "What do you think happens next?" or "How do you think the character feels?''
10. After the story, ask for volunteers to play different characters. Assign roles to each child, ensuring everyone who wants to participate gets a part.
11. Revist the story in subsequent sessions, allowing different children to take on new roles.

Learning Outcomes: Enhances vocabulary, sentence structure, and comprehension through listening and speaking. Encourages children to express emotions and understand the feelings of others. Promotes cooperation, turn-taking, and collaborative play. Fosters creative thinking and imaginative play. Helps children remember and sequence events in a story, enhancing cognitive development.

Skill Set (HDFS) 3: Shoe lacing board for a fine motor skills activity

Materials Required : Cardboard or hardboard, Scissors, Hole punch, Shoelace or yarn, Marker orpen

Procedure:

1. Cut the cardboard or hardboard into a rectangular or shoe-like shape. The size can vary based on preference, but it should be large enough for easy handling.
2. Use a marker or pen to draw the outline of a shoe on the cardboard. This can be a simple representation of a shoe, including the sole, sides, and top.
3. Cut along the outline to create the shoe shape. Ensure smooth edges to prevent any sharp points.
4. Along the edges of the shoe shape, use a marker to mark evenly spaced points where the lacing holes will be. Start with holes near the top of the shoe, going down the sides and around the edges.
5. Use a hole punch to create holes at the marked points. Ensure that the holes are large enough to easily thread the shoelace or yarn through.
6. Cut a shoelace or a piece of yarn that is long enough to go through all the holes on the lacing board. Tie a knot at one end to prevent it from slipping through.

7. Demonstrate how to thread the shoelace through the holes, following the pattern of the shoe. Encourage children to start from one end, weaving through each hole until they reach the other end.
8. Allow children to practice lacing and un-lacing the shoe, promoting fine motor skill development and hand-eye coordination.

Learning Outcomes: Enhances fine motor skills and hand-eye coordination.

FISHERIES

Skill Set (AQC) 1: Backyard seed production and hatchery management of pabda (*Ompok bimaculatus*)

Skills to impart:

i) Broodstock Management, ii) Induced Breeding Techniques, iii) Egg Incubation and Hatching, iv) Larval Rearing, v) Water Quality Management, vi) Handling and Prevention of Cannabilism, and vii) Economics and Scaling Up Production

Tools and materials:

Pabda brood fish, inducing hormone (Ovatide), Sterile 1ml syringe, Scissors and forceps, plastic tray (36 cm x24 cm x 6.5 cm), fabricated net caging prepared withlow cost bamboo or iron frame, bamboo frame with polythene sheet (2m x 1m), dried fish eggs, air pump, plastic tub (20l), bucket, nylone hapa (3 m x 4m), glass aquarium (250 litres), and net baskets

Season of propagation: June to August
Ideal climate: 25-30 ºC
Technical Know-How:

1. Broodstock Management:

- Selection: Choose healthy Pabda brood fish with an average weight of 80-120 g.
- Conditioning: Raise the brood fish on a high protein diet (36% crude protein) enriched with essential fatty acids and vitamins.
- Maintenance: Keep broodstock in a hapa (2m x 1m) before and after injection.

2.Inducing Breeding Techniques:

- **Hormone Injection:** Administer inducing hormone (Ovatide/OvaFH/Gonopro etc.) at 2.0 ml/kg body weight for females and half of this dosage for males.
- **Spawning and egg collection**:
- After injecting, the fishes are released into the fabricated net caging prepared with low-cost bamboo or iron frame and set into the cemented tank of 3 x 3 meters.
- A gentle water flow is maintained with provision of running water flow using an overhead shower.
- Under normal condition, spawning occurs after 10 hours of hormonal injection. After the release of the eggs, the netting cage containing the brooders can be carefully removed, and fishes can be shifted to the brood-stock tanks.
- The fertilized eggs can be aggregated by gentle stirring, and then slowly siphoned out using a plastic pipe into an egg collection tub.

3. Egg Incubation and Hatching:

- **Setup**: Use a bamboo frame with a polythene sheet to create a water-holding system (Low-Cost System). OR use glass aquariums.
- **Distribution**: Place fertilized eggs in net baskets within the water holding systems
- **Conditions**: Maintain water temperature at 27-30 °C and a depth of 14-15 cm.
- **Hatching**: Eggs hatch within 24 hours, with a hatching rate of 60-80%.

4. Larval Rearing:

- **Initial Care**: After hatching, take out the net baskets with eggshells. Put mild aeration in the incubation tank.
- **Feeding**: Feed larvae after 2 days of hatching with live plankton and finely chopped tubifex larvae after yolk sac absorption. Gradually introduce powdered dried fish eggs.
- **Density Management**: Maintain a stocking density of 10 larvae/l for optimal growth.

5. Water Quality Management:

- **Parameters**:
    - Dissolved oxygen: 6.0 – 7.5 mg/l
    - Temperature: 25-32 °C
    - pH: 7.0 -8.0
    - Carbon dioxide: 2.0-3.5 mg/l
    - Total alkalinity: 25-40 mg/l
    - Hardness: <50.0 mg/l
    - Ammonia: < 0.03 mg/l
- **Maintenance**: Ensure daily water exchange (50%) with mature groundwater.

6. Handling and Prevention of Cannibalism:

- **Observation**: Monitor for cannibalism from the second day of rearing.
- **Management**: Thin out the density and segregate based on size. Provide hideouts to control cannibalistic behavior.
- **Feeding Frequency**: Feed larvae four times a day.

7. Economics and Scaling Up Production:

- **Investment**: Initial investment of Rs. 10,000.
- **Returns**: Potential to generate Rs. 50,000 from seed sales.
- **Scaling**: Increase production based on broodstock availability and facility size.

Skill Set (AQC) 2: Proximate composition analysis

Skill to impart: To impart skills about proximate composition analysis such as moisture, dry matter, ash, crude protein, crude lipid, crude fiber and nitrogen-free extract content of feed and feed ingredients.

1. Moisture Content Estimation

Materials: Electronic balance, Hot air oven, Crucible, and desiccator.

Procedure:

a. **Sample preparation***:* Weight approx. 10-20 grams of sample. Place the sample in a pre-weighed crucible.
b. **Drying:** Dry it in an oven at 105°C for 24 hours.
c. **Weighing**: Remove the sample, cool it in a desiccator, and reweight.

Calculation:

$$\text{Moisture Content (\%)} = \frac{\text{Initial weight of sample} - \text{Weight after drying}}{\text{The initial weight of sample}} \times 100$$

2. Dry Matter Content Estimation

After calculation of percentage of moisture content, the dry matter content can be calculated using the following formula:

Calculation: DM (%) = 100% −Moisture Content (%)

2. Ash Content Estimation (Muffle Furnace)

Materials: Electronic balance, muffle furnace, crucible, and desiccator.

Procedure:

a. **Sample preparation***:* Weigh 10-20 grams of the dried sample in a pre-weighed crucible.
b. **Burning:** Place the sample in a muffle furnace, and incinerate at 550°C for 4-6 hours.
c. **Weighing**: Cool the crucible in a desiccator and reweight.

Calculation: Ash Content (%) = (Weight of ash/Weight of sample) ×100

3. Crude Lipid (Fat) Content Estimation (Soxhlet Extraction Method)

Apparatus: Electronic balance, Soxtech system, extraction beaker, thimble, thimble holder, hot air oven:

Reagents: Petroleum ether (40-60ºC boiling point)

Procedure:

a. **Sample preparation*:*** Weigh 2-3 g of the dried, ground sample, transfer to a cellulose thimble, and place in a beaker.
b. **Extraction*:*** Add petroleum ether to 2/3 of the beaker. Place in the Soxhlet extractor set at 70-80 °C for 1.5 hours, and then collect the solvent after 4-6 hours by closing the stopper.

c. **Evaporation**: Remove thimble, place beaker in 105 °C oven to evaporate solvent.

d. **Weighing*:*** Cool the beaker in a desiccator and reweigh it with the extracted fat.

Calculation:

Crude Lipid Content (%) = Weight of extracted fat×100

Weight of sample

4. Crude Protein Content Estimation (Kjeldahl Method*)*

Materials: Digester, distillation unit, digestion tube, conical flask, beaker, burette, and burette stand.

Chemicals required: Conc. H_2SO_4, digestion mixture (K_2SO_4 or Na_2SO_4, $CUSO_4$, $5H_2O$, and metallic selenium), boric acid, 40% NaOH, HCL, and mix indicator.

Procedure:

a. **Sample preparation:** Weigh 0.5 g plant or 0.2 g animal sample, transfer to digestion tube, add 5-7 g digestion mixture and 10-15 ml sulfuric acid.

b. **Digestion:** Place the tubes in the digestion chamber, open the water taps, and switch on the chamber. Digest for 3-4 hours at 360-410 °C.

c. **Distillation. S**tart the distillation unit, release water, and insert the digestion tube. Prepare 25 ml boric acid with indicator in a 250 ml flask, and place at the receiver end.

d. **Titration:** Titrate the boric acid solution with a standard acid solution (0.1 or 0.2 M) to determine the amount of nitrogen.

Calculation: Crude Protein Content (%) = Nitrogen content×6.25

(The factor 6.25 is based on the average nitrogen content of proteins, which is approximately 16%.)

5. Crude Fiber Content Estimation (Fibertech method)

Apparatus: Fiber Extraction system, sieve, pipette, hot air oven, muffle furnace, top loading balance and analytical balance, and desiccator.

Reagents: Acetone, petroleum ether, 1.25% sulphuric acid and 1.25% NaOH

Procedure:

a. **Sample preparation:** Grind and sieve the sample. Defeat if fat exceeds 1%; not necessary if 1% or less.

b. **Weighing:** Weigh the empty Fiber Cap capsule and sample, then place it in the tray move to

the and carousel and put the stopper.

c. Extraction and filtration:

- Hot acid extraction: Boil in 350 ml of 1.25% H_2SO_4 for 30 min
- Washing and filtration: Rinse the capsule with 350 ml boiling water, and repeat thrice.
- Neutral detergent extraction: Boil in 350 ml of 1.25% NaOH boiling for 30 min
- Washing and filtration: Wash the capsule with 350 ml boiling water, and repeat thrice.
- Repeat neutral detergent extraction: Perform the above step thrice with 1.25% NaOH.

d. **Drying and weighing:** Dry the final residue, then weigh the capsule.

a. **Ashing and weighing:** Re-weight after incineration in a muffle furnace at 550 °C for 4-6 hours.

Calculation:

Crude Fiber **(%)** = $\frac{\text{(Weight of residue after drying} - \text{Weight of residues after ashing)} \times 100}{\text{Initial weight of sample)}}$

6. Nitrogen-Free Extract (NFE)

Nitrogen-free extract (NFE) represents the digestible carbohydrates in feed and is calculated as follows:

Calculation:

NFE (%) = 100%− (Moisture (%) + Ash (%) + Crude Protein (%) + Crude Fat (%) +Crude Fiber (%)

FISH GENETIC RESOURCES

Skill Set (FGR) 1: Hatchery operation for production of carp spawn and seed

Skills to impart:

Broodstock Management, Induced Breeding Techniques, Egg Incubation and Hatching, Water Quality Management, Packing and transportation for fish seeds.

Water area: 1.0 ha

Equipment: Eco-hatchery unit: One breeding pool, one egg collection chamber, two incubation pool with each spawn collection chamber, one overhead tank and pipes.

Materials

i)Brood fish: Carps: rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*), ii) Inducing hormone (Ovatide), iii) Sterile 1 ml syringe, iv) Collection Hapa, v) Measuring bowl, vi) Oxygen cylinder ,vii)Polythene packet and tying rope, and viii) Carton box

Season: May to August

Age of brooders at maturity: 2+ years

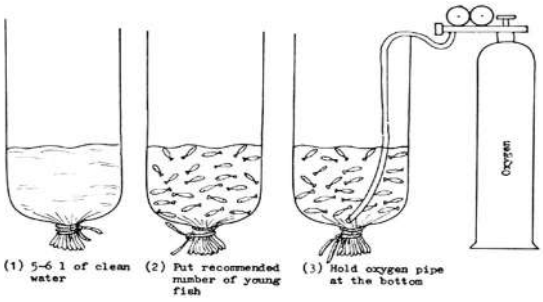
Ideal water parameters of hatchery: Temp (27-34 ºC); DO (3.0-5.5 mg/l); pH (7.2-8.25); total alkalinity (54.0-80.0 mg/l); total hardness (46.0-94.0 mg/l)

Broodstock management: Brooder fishes are fed with 30% protein containing supplementary feed @ 2% body weight daily.

Sex dimorphism: Brooders are selected from brood stock pond and their sexes are identified based on morphological characters. Females have well round swollen abdomen, pinkish vent and smooth pectoral fin while males have rough pectoral fin in male and mature male release few drops of milt when abdomen is pressed slightly.

Steps of hatchery operation:

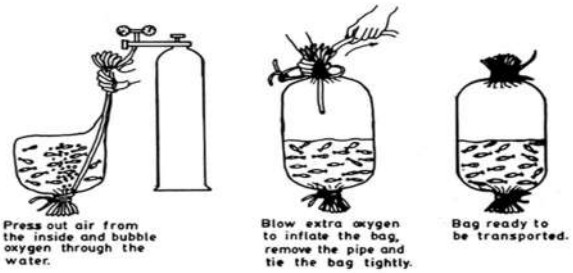
- Clean the pools with $KMnO_4$
- Close valves and fill with water
- Inject the fishes with hormones. Male and female brooders are injected @ 0.2 ml/kg and 0.5 ml/kg body weight, respectively via intra-peritoneal in a single dose
- Release the injected fishes in the breeding pool @ male: female brooders ratio of 1:1 and run the shower. Cover pool with net to prevent fish from jumping out
- After 4-5 hours of injection, remove outlet valve and collect eggs from the egg collection chamber. Remove brooders and release to pond after dipping in $KMnO_4$ @ 5 ppm
- Put screen on the inner socket of the hatching pool and fill it with water and maintain water circulation through duck-mouth inlets



- Release the eggs, after measuring volume, into the hatching pools
- Collect the spawn on 4th day through the spawn collection tank

Packing and transportation:

- Spawn, fry and older fish for long transportation have to be conditioned and should not be fed
- Take a 50L capacity polythene bag
- Polythene bags are kept in a carton box and about 20L or 1/3 of its capacity is filled with aerated pond water
- Oxygen volume should be filled @30L or 2/3 of the polythene bag
- Fish spawn is pack @ 40000 to 80000nos per bag
- Seal the bag tight
- Suitable for transport duration of 12 to 24 hr.



Skill set (FGR)-2: Carp fish spawn rearing for production of fingerlings

- **Skills to impart:** Pond preparation
- Management of nursery and rearing ponds
- Feeding management of carp spawn and fry
- Production of quality seed of carps

Ponds/Tanks:

- Nursery pond (0.010 ha with depth of 1.0 m)
- Rearing pond (0.02 ha with depth of 1.5 m)

Materials:

- Carp fish spawn
- Supplementary feed
- Cow dung
- Lime

Season: May to August

Ideal water parameters of pond:

Temp (27-34 ºC); DO (3.0-5.5 mg/l); pH (7.2-8.25); total alkalinity (54.0-80.0 mg/l); Total hardness (46.0-94.0 mg/l)

Technical knowhow:

- Drying and manuring of ponds:
  i)Ponds are dried and add lime @ 25-50 kg/ha
  ii) Refill pond with water before 4-7 days of stocking
  iii)Add 500-625 kg cow dung manure/ha
- Releasing of fish spawn in tanks and nursery ponds
  - Fish spawn are released @15-25Lakh/ha
- Feeding of fish seeds in nursery ponds
  - Feed with MOC: Rice bran @1:1 @3-4% body weight
- Harvesting of fish seeds (Fry/Fingerlings)
  - Fry/fingerlings are harvest after 15-20 days when they attain size of 20-25mm

Packing and transportation:

- Spawn, fry and older fish for long transportation have to be conditioned and should not be fed
- Take 50 L capacity polythene bag
- Polythene bags are kept in a carton box and about 20 L or 1/3 of its capacity is filled with aerated pond water.
- Oxygen volume should be filled @30 L or 2/3 of the polythene bag
- Fish fingerling size of 1-5 g size are pack @ 2000 nos. per bag
- Seal the bag tight. Best for transport duration of 12 to 24 hours.

Skill set (FGR)-3: Seed production of giant freshwater prawn (GFP)/ scampi

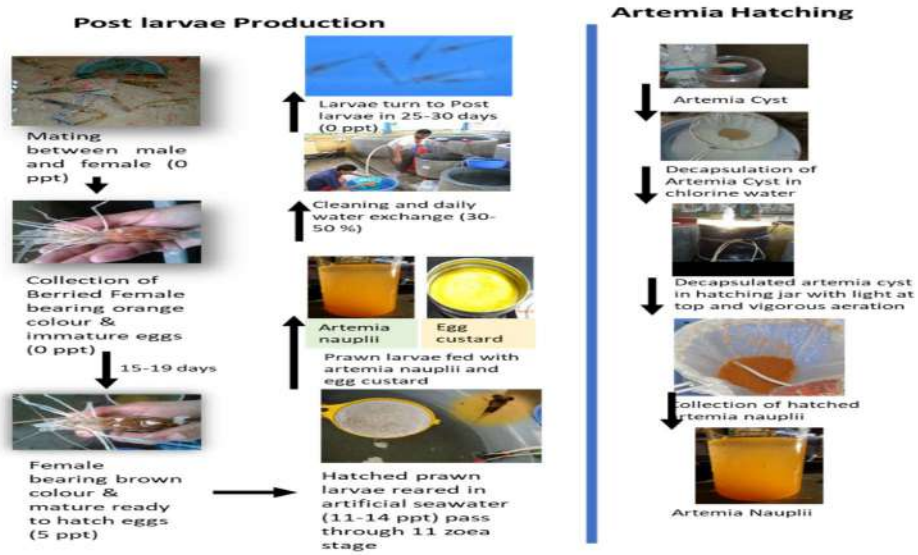
Skills to impart: Seed production technology for Giant freshwater prawn (GFP)/Scampi

Tools and materials: Hatchery shed, larval rearing tank, seawater & freshwater tank, biofilter, aerator, artemia hatching unit, refrigerator, Salinometer, Salts.

Brood stock: Giant freshwater prawn (*Macrobrachium rosenbergii*)

Season of breeding: April to August

Ideal climate: 26 - 35 ^{0}C



Raising of broodstock:

- Berried females of scampi (bearing orange colour eggs) are collected from pond
- Reared in isolation in FRP tank or bucket and fed over chopped molluscs meat, sinking feed.

Steps involved in larval rearing and post larval (PL) production:

- Larvae hatching occur after 2-3 days once the eggs turn from orange to dark brown colour.
- Collected larvae are being reared in 11-14 ppt synthetic seawater with aeration in U-bottom cistern/FRP tank (100-300 liter).
- Larvae are fed over artemia nauplii and egg custard.
- Larvae pass through 11 zoeal stages and turn to post-larvae in 21-30 days depending on water temperature.
- Post larvae are transferred to freshwater pond for grow out.

Skill set (FGR) 4: Production of magur (Catfish) seed

Skills to impart: Induced breeding and seed production technology for Magur (Catfish)

Tools and materials: Hatchery shed, Brood magur, flow through hatching unit, fry rearing tank, feed, overhead tank, inducing agent.

Broodstock: Magur (*Clarias magur)*

Season of breeding: June to August

Ideal climate: 26 - 35 ^{0}C

Raising of Broodstock:

- Collection of 1+ year male and female and rearing in cistern tank @ 4-5/meter sq.

- Brooders are fed feed with 35% or more protein for 90 days before the commencement of hatchery operation.

Steps involved in seed production:

- Select a female with a bulging belly and oozing eggs (on gentle pressure) and male with an elongated genital papilla.
- Inject both with the inducing agent @ 0.5-0.8 ml/kg body weight.
- After 16-18 hours, strip females to collect eggs in a dry bowl.
- Simultaneously sacrifice male to collect testis
- Macerate the testis in 0.9% NaCl and mixed with the eggs.
- Add small amount of water and mixed with the feather.
- Placed the fertilized eggs in flow through hatching unit.
- After 27 hours of incubation, hatchlings are transferred in rearing tank (water depth 10 cm) with sufficient hide out.
- Fry should be fed with zooplanktons, artemia nauplius, and egg custard
- Fry reach to size of 2-3 cm in one month and sold for grow out culture.

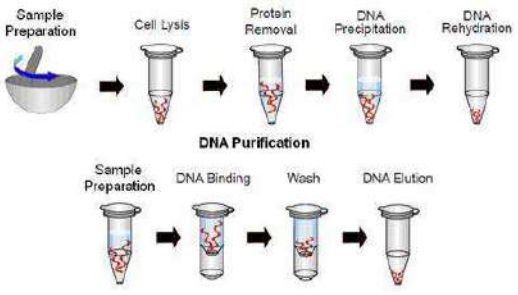
Skill Set (FGR)-5: Molecular biological technique for fish

Skills to impart: DNA isolation, RNA isolation, Plasmid isolation, Cloning, PCR and RT PCR, Agarose Gel Electrophoresis, PAGE

Tools and materials: Refrigerated Centrifuge, Biphotometer, Sonicator, PCR machine, RT PCR machine, Gel Doc, Deep freezer, AGE and PAGE apparatus, Shaking Incubator

Technical knowhow:

i)DNA isolation:



- Take tissue and mascerate
- Take 2 ml of the lysate and add 10% SDS and 5µl Proteinase K
- Keep at 37 ºC for 1 hour
- Add 1ml phenol-chloroform mixture, mix well and keep at RT for 5 min
- Centrifuge @ 10,000rpm for 10 min at 4ºC
- Transfer supernatant to fresh tube
- Add 100 µl of 5M sodium acetate and mix gently
- Add 2ml isopropanol and mix gently till DNA precipitates
- Centrifuge @ 5000 rpm for 10 min
- Discard the supernatant
- Add 1ml of 70% ethanol
- Centrifuge @ 5000 rpm for 10 min
- Discard the ethanol and air dry the precipitate for 10 min
- Add 200 µl TE buffer or DNAse-free distilled water
- 10 µl of DNA sample is taken and diluted to 1 or 2 ml with distilled water
- The concentration of DNA is determined using a spectrophotometer at 260/280 nm.

ii)RNA isolation:

- Tissue or cell suspension kept in RT for 5 min
- Add chloroform 200 µL
- Vortex and leave at RT 15 min
- Centrifuge @ 12000 rpm, 15 min at 4 ºC
- Collect the supernatant (upper phase) in e-tube
- Mix with isopropyl alcohol (2-propanol) 500 µL and vortex
- Leave at RT 10 min (optional)
- Centrifuge at 12000 rpm, 10 min at 4ºC
- Remove the supernatant and keep RNA pellet (bottom part, white colour)
- Wash the residue (RNA pellet) with 75% EtOH 1 mL and vortex
- Centrifuge @ 7500 rpm, 5 min at 4 ºC and remove the EtOH
- Air dry for 3-5 min then add 20 µL RNAse free water
- Heat at 60ºC for 10 min > taking 2 µL sample measure RNA concentration
- RNA sample is kept at -70 ºC

iii)Plasmid DNA isolation:

- Take 2 ml of plasmid culture in Eppendorf tube and add antibiotic
- Keep overnight
- Centrifuge @ 5000 g for 5 min at room temperature
- Remove supernatant
- Resuspend with 200 µL (lysozyme and tris HCL solution)
- Keep at room temperature for 5mins
- Add 400 µL solution of 0.2 M NaOH and 1% SDS
- Invert tube
- Add 200 µL of fresh solution of 8 M sodium acetate
- Mix by pipetting
- Keep in ice for 4 min
- Centrifuge @ 10000 g for 5mins
- Transfer supernatant carefully to new tube

- Add 0.6 ml isopropanol for 1 ml supernatant
- Mix
- Centrifuge @ 10000g for 5 min
- Discard supernatant
- Wash pellet with 70% ethanol
- Centrifuge @ 10000g for 5 min
- Remove supernatant
- Air dry pellet
- Resuspend in 30-50 µL of tris HCl or distilled water with 1 µL RNAse
- Store at -20 ºC

iv)Polymerase Chain Reaction (PCR):

For 20 µl reaction

- µl of dsDNA template
- 2 µl of 10X buffer
- 1 µl of 4 mM dNTP mix
- 1 µl of 10 µM forward primer
- 1 µl of 10 µM reverse primer
- 13 µl of water
- Mix well in ice

Set thermal cycler program

- Step 1: 94 °C .....3 min 1 cycle
- Step 2: 94 °C .....30 sec 32 cycles
- Step 3: 60 °C .....30 sec 32 cycles
- Step 4: 72 ºC.....1 min 30 sec 32 cycles
- Step 5: 72 ºC..... 10 min 1 cycle
- Step 6: 4 ºC holding of sample until analysis by gel electrophoresis
- Run the PCR

v)Real-time PCR or qRT-PCR:

Prepare mix (20 µl)

- Template: cDNA 6.8 µl
- 2 x SYBR Green mix 10 µl
- 5µM primer Forward 0.8 µl
- 5µM primer Reverse 0.8 µl
- H_2O 1.6 µl

Set thermal cycler program

- Step 1: 50 °C .....2 min 1 cycle
- Step 2: 95 °C .....10 min 1 cycle
- Step 3: 95 °C .....15 sec 40 cycles
- Step 4: 60 °C .....1 min 40 cycles
- Run the PCR

vi)Gel Electrophoresis:

- Prepare 0.75% agarose gel for DNA; 2% for RNA separation and 3% for qRT-PCR
- Add in 40 ml 1x TAE buffer
- Heat and let it cool
- Add 1-2 µL ethidium bromide

- Pour gel into caster and let to solidify
- Pour 1x TAE buffer in the electrophoresis buffer tank
- Add the solidified gel inside the tank
- Load 5 µL sample with 1 µL loading buffer
- Load ladder in a well for reference
- Run at 75v for 20-30 min
- Observe the gel under GelDoc or UV transilluminator

FISH PROCESSING TECHNOLOGY

Skillset (FPT) 1: Bio-chemical analysis of fish and fishery products

Skills to impart: Proximate analysis of the fish and Fishery Products

Tools: Kjeldhal digestion & distillation unit, hot air oven, Soxhlet apparatus, and muffle furnace, weighing balance, knife, and chopping board.

Materials: Fish and Fishery Products sample (nearly 100 g), H_2SO_4, NaOH, Boric acid, etc.

1. **Steps involve Protein estimation:**

- Nearly 1 g fish sample was digested on the heat in H_2SO_4 until it turned into a transparent colour.
- Further, the sample is made up to 50 or 100 ml using volumetric flask
- From made sample 2 to 5 ml is taken for distillation
- The sample is heated in a distillation unit in the presence of NaOH. This helps to liberate the nitrogen and trapped into boric acid.
- Consequently, the titration is performed using HCL/ H_2SO_4, and nitrogen is calculated using a formula. The nitrogen value is multiplied by 6.25 to arrive at the protein value in the fish and Fishery Products

2. **Steps involve moisture estimation:**

- Around 10 g fish sample is weighed and kept at 100 °C for drying in a hot air oven for 24 hours.
- The moisture is calculated by the difference in weight before and after drying.

3. **Steps involve fat estimation:**
   - Around 1 g sample is weighed using a weighing balance.
   - The sample was kept in a cellulose thimble and fitted in the Soxhlet unit for fat extraction using petroleum ether.

- The extraction is kept on until 15-16 hours at 40-50 °C.
- The difference in weight of the receiving flask, pre and post-extraction is noted down to calculate the fat content in the given sample.

4. **Steps involving ash estimation:**

- Around 1 g dried sample is weighed and burned in a crucible until smoke formation is stopped.
- The burned sample is kept in muffle furnace already set at 550 ^{0}C for 5-6 hours or until sample becomes ash white.
- The difference in weight pre and post-burning is calculated using a formula.

Moisture analysis | Fat analysis | Ash analysis

Skillset (FPT) 2: Fishing gear fabrication

Skills to impart: Making different types of net for fishing.

Tools and materials: Gauge, Needle, Twine, Twine cutting knife, Netting rod, Floater, Sinker, Netting thread and twine.

Net Making Procedure

1. Prepare the Twine:
- Cut the twine to the desired length for the net using the twine cutting knife.
- Load the netting needle with the twine, ensuring it is securely wound.

2. Set Up the Netting Rod:
- Secure the netting rod in a stable position. This rod will serve as the foundation for the initial row of meshes.

3. Create the First Row:
- Use the netting gauge to determine the size of the mesh.
- Loop the twine around the netting rod and tie the first knot, forming the initial mesh.
- Repeat this process along the length of the netting rod, ensuring consistent mesh size.

4. Form Subsequent Rows:
- Move the netting gauge down to the next row position.
- Tie the twine from the first row into the second row by looping and knotting it through the previous row's meshes.
- Continue this process, moving the gauge and creating new rows, maintaining even tension and consistent mesh sizes.

5. Incorporate Floaters and Sinkers:

- As you progress, attach floaters to the top edge of the net to keep it buoyant.
- Attach sinkers to the bottom edge of the net to ensure it sinks properly.
- Distribute floaters and sinkers evenly along the edges for balanced performance.

6. Finalize the Net:

- Once the desired length and width of the net are achieved, secure the final row of meshes with tight knots.
- Inspect the net for any loose knots or irregular meshes, making necessary adjustments.

7. Trim Excess Twine:

- Carefully trim any excess twine using the twine cutting knife, ensuring all knots are secure and ends are neat.

8. Test the Net:

- Test the net for strength and functionality by gently pulling and stretching it.
- Ensure that the net maintains its shape and the meshes do not deform or break.

9. Make Adjustments:

- If any issues are found during testing, make necessary repairs or adjustments.
- Reinforce weak points with additional knots or stitching as needed.

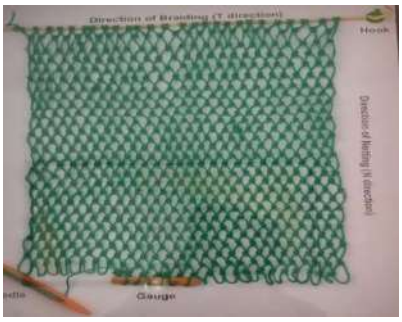
10. Store Properly:

- Once the net is complete and tested, store it in a dry, cool place to prevent damage.
- Ensure the net is clean and free of debris before storing.

Tools and accessories for gear fabrication

Gear fabrication by students

Fabrication of cast net



Hand breading of netting

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