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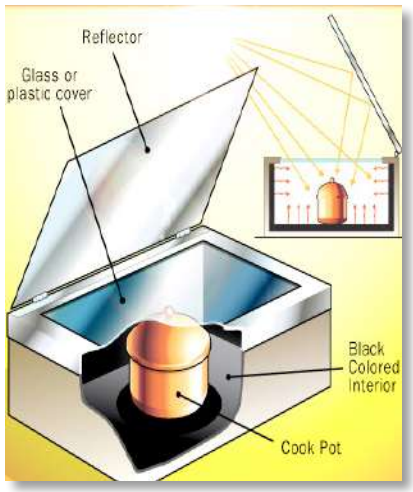

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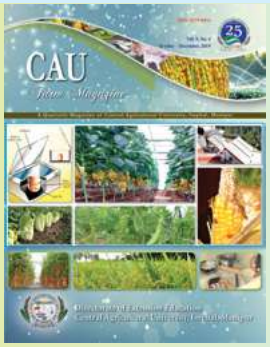

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From the Editor's Desk

Central Agricultural University, Imphal has been striving to its level best to provide a better quality of education, need-based research inputs and training to the farmers, farm women, rural youths and extension personnel since inception for the betterment of rural mass in the NE Region. Extension Education of the University emphasizes on making awareness opens the avenue to all farming communities to utilize all kinds of services being available in its jurisdiction through constituent colleges and Krishi Vigyan Kendras. To go ahead in achieving the goal, the regular quarterly publication of CAU Farm Magazine has encouraged the academic fraternity of universities, colleges, research institutes and KVKs in serving the farming community.

Being a quarterly publication, we try at our level best to incorporate important, useful, need-based timely information to the farmers and other stakeholders who directly or indirectly involved in farming. Accordingly, in this Vol. 9, No. 4 total thirteen (13) nos. of varied nature of articles contributed by the learned teachers, scientists, and extension specialists have been incorporated. The articles mainly covered the areas about the success of CAU R1 rice variety, resource conservation technology, low-cost technology for mushroom, role of renewable energy, options for increasing farmers' income, fall armyworm, insect pest management of citrus, mechanization of rapeseed-mustard cultivation, insect pest management of maize, antioxidants, wetlands as carbon sink, promising exotic vegetables, and status of livestock in Nagaland.

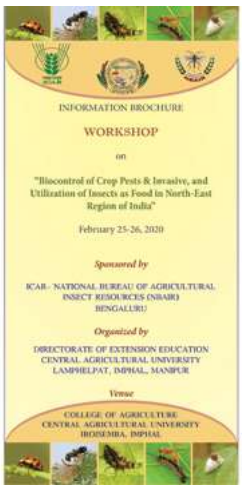
I hope the readers of the magazine will go through the subject matters inherent in the issue and disseminate the information to others for their proper use. I would like to inform our readers that we have tried to include valuable articles in a simple, and understandable way but even, if you feel any suggestion, may please communicate the same to us without any hesitation for improvement and enrichment of the contents in the future issues.

Further, I would like to request to all the contributors please strictly follow the appended 'Authors Guidelines' of this magazine and also invites more and more field-based articles/ success stories/ ITKs /farm innovations/ new proven technologies/ new ideas and so on for the benefit of our resource-poor farmers of the remotest corner of this country.

As Chief Editor, I would like to express my deep scene of gratitude to our own Hon'ble Vice-Chancellor and Patron of the Editorial Board, Prof. M. Premjit Singh for his keen interest on the CAU Farm Magazine and also thankful to all the members of Advisory Board; Editor, Dr. Dipak Nath, Dy. Director (EE), and Asst. Editor, Dr. Indira Thounaojam, IPO. Thanks, are equally due to Mr. Y. Premchand Singh, Computer Operator, and Mr. G. Amritkumar Sharma, Video-photographer for their untiring contribution to bringing this issue on time.

We solicit your suggestions and feedback for making our mission a feat.

(Prof. Ratan Kumar Saha)
Chief Editor

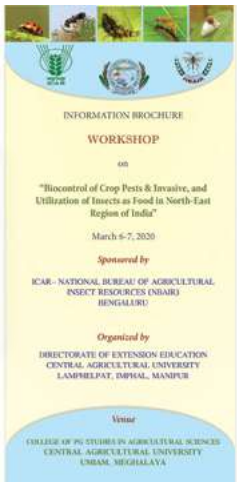


UPCOMING EVENTS

FARMERS FIELD DAY 2019-20

ON

February 18, 2020



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ISSN : 2279-0454
October - December, 2019

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October - December, 2019

VOL. 9, NO. 4

CONTENTS

ISSN : 2279-0454
October - December, 2019

1

CAU R1 (TAMPHAPHOU) - A VARIETY DEVELOPED BY CENTRAL AGRICULTURAL UNIVERSITY, IMPHAL HAS RETURNED MORE THAN WHAT IS SPENT

N. Ganeshamurthy[1], M. Premjit Singh[2], R. K. Saha[2], E. V. D. Sastry[1], Ph. Ranjit Sharma[1], K. Noren Singh[3], Th. Robindro Singh[2], Th. Renuka Devi[1] and K. S. Shashidhar[2]

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Rice is the principal food grain crop of the North-Eastern hilly ecosystem. It is grown in varied ecosystems that span high altitudes of Sikkim and Arunachal Pradesh in the North, flood-prone areas of the Brahmaputra and Barak valley of Assam, Manipur in the south of North East. It is also cultivated on uplands, steep terraces, either as rainfed, irrigated or in and deep-water, Jhum and *tilla* land ecologies of North East occupying 3.51 million ha which accounts for more than 80% of the total cultivated area. The total rice production of the NE region (including Assam) is estimated to be around 5.50 million tones with average productivity of 1.57 t ha^{-1}, which is much below the national average of 2.08 t ha^{-1}. The increase in rice production and productivity over the past 30 years is marginal and much below the national average. The NE region is lagging much behind the other advanced states as far as the production and productivity of rice are concerned and it is supposed to be because of different biotic and abiotic stresses that include extreme temperatures at the time of flowering and grain filling stages that result in lower productivity. North East is the cradle for rice biodiversity and a rough estimate indicates that more than 30,000 rice cultivars were grown in the eastern and northeastern parts of India in the past. It is also home to a large number of aromatic and quality rice varieties. The whole region is considered as a veritable treasure trove of rice germplasm with a wide genetic resource. Rice self-sufficiency is about 80% in north-eastern India (Nagachan *et al.,* 2011). States like Assam, Manipur, and Tripura can easily produce surplus rice. Others can improve their production potential and productivity with suitable interventions. Barring Assam, the other seven states prefer glutinous rice. Central Agricultural University, therefore, has been concentrating on improving the yields of semi-glutinous rice and has come out with a series of rice varieties. Of these, four namely, CAU R1, R2, R3, and R4 have already been released for general cultivation. Out of these four varieties, CAU R1 has gained the most popularity in the seven sister and one brother states of NE Region and has revolutionized rice production in these states.

CAU R1 is a cross between Leimaphou x BR-1 (ICARZCU3, 2019). The variety was released in 1999 but was officially notified in 2009. This variety is a medium duration (125-130 days) high yielding rice variety suitable for rain-fed, subtropical wetland paddy fields of North Eastern states of India including Assam. This is mainly a *Kharif* season variety suitable for both direct seeding and transplanting and can tolerate up to 7 days of complete submergence. The variety is non-lodging and non-shattering and performs very well under low fertility levels. The variety was reported to yield optimum even at an applied fertilizer level of 60:40:40 kg NPK ha^{-1}. The variety is tolerant of rice gall midge, rice blast and BLB under field conditions and has a high shelling percentage of 72% brown rice recovery.

Duration and productivity

The variety matures in 125 to 130 days and yields about 5 to 6 t ha^{-1}. In farmer's field competitions, the variety bagged the first position in crop competition during *Kharif* 2009 getting 8.8 t ha^{-1} and in 2014-15 getting 12.3 t ha^{-1} (ICARZ CU3, 2019). But under high nitrogen levels during the reproductive stage, the variety suffers heavily by producing chaffy grains (ICARZCU3, 2019)

ISSN : 2279-0454
October - December, 2019

Grain and cooking quality

This being a semi-glutinous variety has cooking quality meeting the requirements of the rice cooking preference of NE states and has been well accepted by the people as a brand in itself.

Adoption and impact

Owing to its higher yield and unique grain and cooking quality traits, CAU R1 received phenomenal acceptance in the North-Eastern states' farmers. The area under rice cultivation increased from 10.2 lakh ha in 2009 (year of release of the variety CAU R1 for cultivation) to the present 11.71 lakh ha in 2017-18 (**Fig. 1**) and CAU R1 is cultivated on about 70% of the total area (Nagachan *et al.,* 2011**)**. The total rice produced during 2019 was 2.5 million tones (MT), of which CAU R1 contributed 1.75 million tones (**Fig. 2**). The average net income due to the cultivation of CAU R1 is about 40,000 ha^{-1} as compared to Rs. 25,000 ha^{-1} from traditional rice varieties. The area is calculated based on the seed production and possible coverage of the area with the seed produced (Nagachan *et al.,* 2011).

Economic worth

The appropriate variety and quality seed are the critical determinants of agricultural production on which the performance and efficacy of other inputs depend. For sustained and improved productivity, the continuous development of new and improved varieties of crops and an efficient system of production and supply of seeds to farmers are essential. The National Seeds Policy 2002, clearly emphasizes that "It has become evident that to achieve the food production targets of the future, a major effort will be required to enhance the seed replacement rates of various crops. This would require a major increase in the production of quality seeds" (NSP, 2002).

Seed Production and expansion of area under CAU R1

We made some important assumptions while working-out the expansion in the area under CAU R1. Nationally it is estimated that the paddy seed multiplication ratio is of the order of 1:80. It may be mentioned that the breeder seed of CAU R1 has been exclusively produced by the Directorate of Research, CAU, Imphal through its farms and KVKs. Hence, the accessibility to the data was easier. Second, we assumed a seed rate of 40 kg seed ha^{-1}. and worked out the possible acreage occupied by CAU R1 using the breeder seed production figures available with the University. Thirdly, the yield increase due to replacement of rice varieties with CAU R1 was based on the NICRA KVKs field evaluation report which showed that a net one tone paddy rice yield increased per ha. Was the result of varietal replacement with CAU R1? And finally, the economics was worked out by assuming a paddy seed price of Rs. 40 kg^{-1} of seed. The details of the production and spread of CAU R1 and its economic worth is presented in **Table 1**.

Based on these roughly CAU R1 has occupied an average area of 597.3 thousand ha. Between 2009 and 2018 North-East states have grown CAU R1 paddy rice in 375.3 thousand ha of area and produced an additional paddy yield of about 3753 thousand metric tones of paddy. This has generated a total revenue of Rs. 15,012 crores.

These are estimates exclusively made from the data on breeders' seed production. However, those farmers who have used CAU R1 in their fields also have sold seeds to other farmers in their villages and region. This has not been accounted for here due to a lack of any estimate on such spread of CAU R1. If we include this then the worth of CAU R1 is much above Rs.15,012 crores.

Since the inception of CAU in 1993, the Government of India has spent an average of Rs. 200 crores each year for the past 25 years. This roughly amounts to 5000 crores. Apart from producing graduates and postgraduates a single technology of the university "The CAU R1" rice variety itself has returned to the government more than three folds of the amount spent on the university in just 9 years of cultivation of this golden variety.

Table 1 Production and spread of CAU R1 and its economic worth

Year*	Breed-ers seed** (q)	Founda-tion seed* (q)	Certified seed* (q)	Area coverage** 000, ha	Paddy production 000,tones#	Production if local varieties were sown#	Increase in paddy yield over local vari-eties 000,tones#	Benefit Rs.in crores @Rs. 40 kg^{-1}
2011-12	200	16000	1280000	32.00	96.00	64.00	32.00	128
2012-13	4551	364080	29126400	728.16	2184.50	1456.32	728.16	2913
2013-14	1475	118000	9440000	236.00	708.00	462.00	236.00	944
2014-15	2500	200000	16000000	400.00	1200.00	800.00	400.00	1600
2015-16	5100	408000	32640000	816.00	2448.00	1632.00	816.00	3264

ISSN : 2279-0454
October - December, 2019

2016-17	6650	532000	42560000	1064.00	3192.00	2128.00	1064.00	4256
2017-18	2120	169600	13568000	339.20	1017.60	678.40	339.20	1357
2018-19	860	68800	5504000	137.60	412.80	275.20	137.60	550
Total	**23456**	**1876480**	**150118400**	**3752.96**	**11258.90**	**7495.92**	**3752.96**	**15012**
Average	2932	234560	18764800	469.12	1407.36	936.88	-	-

*Seed production started in 2011. Data for 2019 not included; **Based on Paddy seed multiplication ratio of 1:80; ** @ 40 kg seed ha^{-1}; # based on NICRA KVKs field evaluation; Data of 2018-19 is incomplete

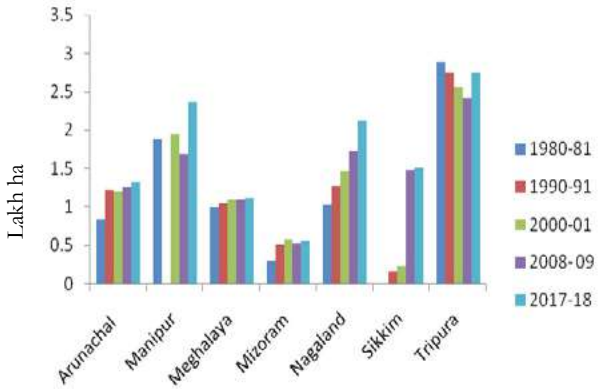

Fig. 1 Trends in the area under paddy cultivation in North Eastern States

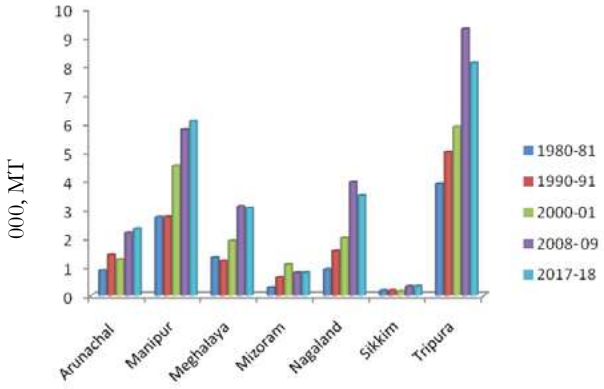

Fig. 2 Trends in the production of rice in North Eastern States

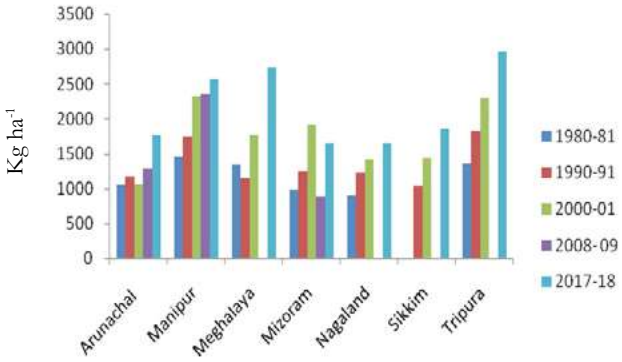

Fig. 3 The Productivity trends of Paddy in North Eastern States

Fig. 4 Semi-glutinous rice variety CAU R1

Conclusion

University's/Institution's success depends upon the quality of the output in terms of successful graduates and the popularization of the technologies emanating from the research work. One such success is brought out in this paper. The semi-glutinous rice variety CAU R1 - a star technology of College of Agriculture, Imphal, CAU has proved that just in nine years of the release of this variety the technology has returned to the government more than three folds of the amount spent on the university in just nine (9) years of cultivation of this golden variety. Hence, strengthening universities and institutions by the government in terms of grants would certainly pay dividends without fail.

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ISSN : 2279-0454
October - December, 2019

2

ENHANCEMENT OF QUALITY AND ECOLOGICAL INTEGRITY OF THE SOIL USING RESOURCE CONSERVATION TECHNOLOGY FOR SUSTAINABLE AGRICULTURE

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Conservation agriculture is a set of practices widely promoted to increase productivity while conserving soil through reduced tillage, mulching and crop rotation. According to Nancy (2001) with little disturbance to the soil is possible to grow the crop. Conserving soil and water, maintaining soil fertility, reducing soil disturbance, improving water infiltration, building up soil organic matter and supporting soil life are among the importance of conservation agriculture. According to FAO (2011) conservation agriculture is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment.

Conservation agriculture emphasizes that the soil is a living body, essential to sustain quality of life on the planet. Conservation agriculture (CA) has been proposed as an adapted set of management principles that assures a more sustainable agricultural production. According to Paneque *et al.* (2019) it is based on three fundamental principles:

1. Reduction in tillage and avoiding mechanical disturbances
2. Maintain crop residues, favoring permanent soil cover
3. Make use of crop rotation.

Conservation Agriculture Techniques

Resource conserving techniques refer to those practices which conserve resources and ensure their optimal utilization and input use-efficiency.

Direct sowing (direct drilling) or Zero-tillage: In this system, soil remains undisturbed from harvest to planting except for nutrient injection. Planting or drilling takes place in a narrow seedbed or slot created by coulters, row cleaners, disk openers, in-row chisels, roto-tillers, zero-till drill and zero-till planter.

Ridge-till: In this system, soil remains undisturbed from harvest to planting except for nutrient injection. Planting takes place in a seedbed prepared on ridges with sweeps, disk openers, coulters, or row cleaners. Residue is left on the surface between ridges. Weed control is by herbicides and/or cultivation. Ridges are rebuilt during cultivation.

Mulch till (reduced tillage): In this system, soil is disturbed prior to planting. Tillage tools such as chisels, field cultivators, disks, sweeps or blades are used. Weed control is by herbicides and/or cultivation. In non-inversion tillage, soil is disturbed (but not inverted) immediately after harvest to partially incorporate crop residues and promote weed seed germination to provide soil cover during the intercrop period. These weeds are later chemically destroyed (using herbicides) and incorporated at sowing, in one pass, with non-inversion drills.

Cover crops: In this system, sowing of appropriate species, or growing spontaneous vegetation, in between rows of trees, or in the period of time in between successive annual crops, as a measure to prevent soil erosion and to control weeds. Cover-crop management generally utilizes herbicides with a minimum environmental impact.

Resource Conservation Technology

Resource Conservation Technology (RCT) employs all modern technologies that enhance the quality and ecological integrity of the soil, but the application of these is tempered with traditional knowledge of soil

ISSN : 2279-0454
October - December, 2019

husbandry gained from generations of successful farmers. The technology suitable to address these issues are termed as RCT. These issues can be suitably handled through efficient farm machines and equipment such as, zero-till- seed drill, zero-till- Planter, Jet -Plough, paddy drum seeder, straw reaper, happy seeder etc.

Equipment Developed Under Resource Conservation Technology By CAEPHT (CAU, Imphal), Ranipool

The equipment developed under resource conservation technology by CAEPHT (CAU, Imphal), Ranipool are as follows:

1. Animal drawn single and two row Zero till drill

These two equipments create a narrow slit for the seed and does not disturb or turn over the soil in the process of seeding the crop like wheat and buckwheat and mustard (Fig. 1 and 2). Both consist of seed box, main frame, two ground wheels, handle and clevis for fitting beam, chain sprocket arrangements for transmitting

Fig. 1 Animal drawn Single row zero till seed

Fig. 2 Animal drawn two rows zero till seed

power to seed feed shaft. These drills are mounted with rigid tines and inverted-T openers and works satisfactorily under anchored stubbles.

2. Animal drawn single and two row zero till planters

These two equipments maintain spacing between seed to seed and row to row and create a narrow slot for the seed and do not disturb or turn over the soil in the process of planting of seed (**Fig. 3** and **4**)(Karma *et al.*, 2015). Both consist of: seed box (trapezoidal shape (PVC Plastic) capacity 1.00 kg for buckwheat seed grain), seed metering mechanism (vertical seed-metering roller (having triangular cells), power transmission system(A medium size (340 mm diameter) lugs wheel fitted with sprocket (size: 6 cm) of 13 teeth. Another sprocket

Fig. 3 Animal drawn Single row zero till planter

Fig. 4 Animal drawn two rows zero till planter

(size: 9 cm) of 19 teeth fitted for seed metering shaft so that the transmission ratio 1.5:1 maintained for accurate seed spacing). These planters' seed box fitted on the frame of the planters. A standard roller chain has 15 mm pitch for transmission of power. Furrow opener: inverted T - Type furrow opener and works satisfactorily under anchored stubbles.

In zero tillage cultivation, by using above equipments, in single pass about 50% saving in cost of operation was observed in sowing/planting operation compared to the traditional practice.

3. JET Plough

Jet plough is used to prepare seed bed for showing seed without much inversion of soil slice (Fig. 5). It also reduces losses of fine particles of the prepared seed bed in hilly region because soil slice in less exposed and fine soil particles directly not come in contact with droplets occurs due to rain. The Jet plough consists of handle, jet, share and beam (overall dimension: handle height 790 mm, width of jet on front 50 mm and rear side 250 mm with length 235 mm, length of share 90 mm, weight: 6.9 kg). The work rate of jet plough is 0.020 ha (200 sq. meter) per hour at average draft of 42 kg corresponding to depth of operation of 120 mm. During field trails, It was observed during field trial that by adoption of animal drawn Jet plough, the cultivable area was better managed. It also reduced the drudgery and could cover comparatively more area. It is made of mild steel which provides more working width (250 mm) compared to the traditional plough (deshi plough) having 100 mm width.

Fig. 5 CAEPHT developed Animal drawn jet plough

Conclusion

In zero tillage cultivation by using animal drawn single and two row zero till planters, in single pass about 50% saving in cost of operation in sowing/planting operation compared to the traditional practice. Use of Jet plough reduces loss of fine particles of the prepared seed bed in hilly region. It also reduces the drudgery and covers comparatively more area compared to the traditional plough.

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October - December, 2019

3

LOW COST TECHNOLOGY FOR GROWING MUSHROOM

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People have harvested mushrooms from the wild for thousand of years for food and medicines. Of the estimated 1.5 million species of fungi, about 10,000 produce the fruiting bodies we call mushrooms. The Chinese first cultivated shiitake (*Lentinula edodes*) mushrooms around 1100 AD, with domestication efforts beginning centuries earlier. Agaricus is the leading mushroom crop worldwide and accounted for 99 % of the 1997 United States' mushroom production. Oyster mushrooms (*Pleurotus* spp.) were more recently domesticated, and now rank second in world production. Shiitake mushrooms, which are very popular in Asian cultures, rank third. Most growers operate small farms and focus on local markets. Mushrooms lend themselves to many different growing systems from simple and inexpensive to highly sophisticated and expensive. This article will provide information on how to raise mushroom with minimal expenditure. It is an easy production technique which the small marginal farmers can easily adopt.

Material Requirement

Substrate

A large number of agriculture, forest and agro-industrial byproducts are useful for growing oyster mushroom. Substrates should be fresh, dry and free from mould infestation. Oyster mushroom can utilize a large number of agro-wastes including straw of wheat, paddy and ragi, stalks and leaves of maize, jowar, bajra, and cotton, sugarcane bagasse, jute and cotton waste, peanut shells, dried grasses, sunflower stalks, used tea leaf and discarded waste paper. It can also be cultivated using industrial wastes like paper mill sludge, coffee by-products, tobacco waste etc. About 1.5 -2.0 kg of good substrate will be required per bag of 80 cm x 40 cm size.

Mushroom Spawn

Three to four week old non-contaminated spawn @ 10 % of dry weight of the substrate is required for the purpose. Spawn of good quality should be collected from a reliable source. Further, the species / variety should be chosen basing on the temperature and relative humidity of the cropping season of the locality. Just prior to use the 200 gm Spawn is extracted from the bottle with hooked iron rod and divided into four parts.

Polythene Bag

Transparent polythene tube of 125-150 gauge with a dimension of 80 cm x 40 cm is suitable for oyster cultivation. Bags of 60 cm x 40 cm may also be used for the purpose. The bags can be reused for the second crop after proper cleaning.

Substrate Preparation

- Chopped the straw to 4-5 cm size by chaff cutter
- Soaking of straw in chalk powder, mixed water 6-8 l @ 1kg $100l^{-1}$ water for pasteaurization.
- Soaking in hot water at 65°C - 70°C or you can boil the substrate for 30 minutes. This pasteaurization method will either killed or suppress the growth of competitor moulds for 25- 40 days after spawning.
- Drain excess water and maintain moisture content of 60°C
- Dry the substrate by spreading it in a clean polythene by leaving it overnight. The floor where you dry the substrate should be sterilized first.

Raising of Bag

One end of polythene is tied with rubber band and 1 part of substrate is put to a height of 15 cm. Substrate is then gently pressed and one part each of spawn (50 g) and supplement (50 g) spread at the periphery close to polythene. Likewise, four such layers are made and the bag is closed at the upper end after pressing the substrate. For a bag out of 2 kg of dry straw, 200 g each spawn and supplement will be used. 15-20 small holes (0.5 cm diameter) should be made on all sides to facilitate gas exchange. Instead of layer spawning,

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October - December, 2019

mixed spawning may also be followed where the required quantity of spawn is mixed with the prepared substrate (soaked straw) and incorporated into the bag. The bags are then incubated in a well ventilated room at 25°C. During the mycelial growth bags should not be opened.

AFTER CARING

Once the mycelium has fully colonized the substrate forming a thick mycelial mat, it is ready for fruiting. Contaminated bags with mould may be discarded while bags with patchy mycelia growth may be left for few more days for completion of the mycelia growth. These bags are opened after 15-16 days. The bundles after opening are arranged on shelves at a distance of 20 cm between each bag in the tier or hanged with plastic rope. Appropriate temperature (20-30^{0}C), humidity (70-80%) and light (200 lux) with good ventilation should be maintained in the cropping room. Bags are watered twice daily depending upon the weather condition.

Harvesting

Primordia (small eggs) appears within 4-5 days of opening the bag that came to the harvestable stage 3-4 days later. The mushrooms should be harvested when the cap begins to fold inwards. Picking is done by twisting the mushroom gently without disturbing the surrounding fruit bodies. Crop should not be watered before harvesting. The second crop appears after 7-10 days. Hence, within 45 days crop period, 3-4 crops are expected. With exception, under suitable growing condition, a biological efficiency of 100% is achieved in commercial farms.

Yield Per Bag: 1.5 - 2.0 kg.

Fig. 1 Chopping straw

Fig. 2 Draining the excess water

Fig. 3 Filling the substrate with spawn

Fig. 4 Tying the top with rubber band

Fig. 5 Fully mature

Oyster mushroom

Commercial mushroom production requires high levels of management input and skill. A common mistake new growers make is to believe that growing mushrooms is easy. Each species requires specialized treatment to produce consistent yields of high-quality, marketable mushrooms. Another common mistake is to start too large and diversify too soon. Trying to learn a single crop is difficult enough, and mastering several different mushroom crops at once may be impossible. Some spawn suppliers offer starter kits and instructions. Using small starter kits will allow you to gain some experience with different mushroom crops with minimum investments in time and money.

ISSN : 2279-0454
October - December, 2019

4

ROLE OF RENEWABLE ENERGY TECHNOLOGIES FOR SUSTAINABLE AGRICULTURE

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Sustainable agriculture is farming in sustainable way i.e. without damaging the environment and future resource generations. Energy is the most important resource for progress and growth of any agriculture. Energy is central to national development process and to provide major vital services that improve human condition – fuel for cooking, light for living, motive power for transport and electricity for modern communication. In agricultural sector, its use is in every form of inputs-seed, fertilizer, agro- chemical for Plant Protection, machinery use for various operations for crop production and processing, household activities and transport. The shortage of energy is an issue in many countries, particularly those in the developing world. Even where conventional energy is plentiful, there is pressure to reduce the amount of fossil fuels used. Concern over global warming is universal and this has focused our attention on utilization conventional sources of energy to be replaced by renewable sources of energy. The renewable sources of energy are sources are solar energy, biomass energy, wind energy, hydro energy, ocean energy, geothermal energy, hydrogen energy. Renewable energy technologies produce sustainable and clean energy from different renewable energy sources.

Solar Energy Technologies

Solar energy is the most readily available and free energy source since prehistoric times. Sun radiates 180 billion MW of energy over the earth. Solar energy can be utilized through two different routes, as solar thermal route and solar photovoltaic routes. Solar thermal route uses the sun's heat to produce hot water or air, cook food, drying materials, etc. Solar photovoltaic uses sun's heat to produce electricity for lighting homes and building, running motors, pumps, electric appliances and lighting.

Solar Drying Technology

The solar dryer is a device which uses solar energy for drying. The solar dryers have many applications in industries and agriculture. Traditionally, drying of agricultural products is done on the open ground directly under the Sun. This method is known as open sun drying. This leads to losses due to uncontrolled drying, besides causing contaminated of the product. Various types of solar dryers have been developed as an alternative to open sun drying and other conventional drying methods. The College of Agricultural Engineering and Post Harvest Technology, CAU, Ranipool, Gangtok, Sikkim has been developed a Portable Solar PV powered force convection solar dryer, which is suitable for drying of 5 kg vegetables particularly chilly per batch at domestic level was developed. The maximum and minimum temperatures under full load condition for upper and lower tray were 65.3°C and 56.5°C respectively against the respective maximum and minimum ambient temperatures of 27.9°C and 17.2°C. The drying rate of chilly varied in range of 0.01-0.11 kg h^{-1}. **Fig. 1** show the portable solar PV powered force convection solar dryer loaded with chilly.

Fig. 1 Portable solar PV powered force convection solar dryer loaded with chilly

Solar Water Heater Technology

Most solar water heating systems have two main parts: a solar collector and a storage tank. The most common

solar collector is called a flat plate solar collector. It consists of a thin flat, rectangular box with a transparent cover that faces the sun,

Fig. 2 Thermosyphon type flat plate collector solar water heater

mounted on the roof of building or home. Small tubes run through the box and carry the fluid-either water or other fluid, such as an antifreeze solution to be heated. The tubes are attached to an absorber plate, which is painted with special coating to absorb the heat. The heat builds up in the collector, which is passed to the fluid passing through the tubes. An insulated storage tank holds the hot water. Presently, the solar water heater is used for domestic, commercial and industrial applications. A temperature of 60°C is sufficient for domestic use. Most domestic solar water heaters are capacity ranging from 100-500 litres of hot water per day. A typical solar water heater can save up to 1500 units of electricity every year, for every 100 litres per day of solar water heater. A solar water heater of 100 litres capacity can prevent emission of 1.5 tons of carbon dioxide per year. Solar water heater has a life of 15 to 20 years and pays back the cost in 3 to 4 years when electricity is replaced. Solar water heaters are ranging from 100 litres per day to over 20,000 l day^{-1} capacity at 85°C to 90°C have been installed in hostels, guest houses, hotels, industries, etc. The College of Agricultural Engineering and Post Harvest Technology, CAU, Ranipool, Gangtok, Sikkim has been installed 8 (7 units of 1000 litre and 1 unit of 500 litre) natural circulation solar water heaters. The thermosyphon type flat plate collector solar water heater is shown in **Fig. 2**.

Solar Water Pumping Technology

Water pumping is one of the simplest and most appropriate uses for photovoltaic. From crop irrigation to stock watering to domestic uses, photovoltaic-powered pumping systems meet a broad range of water needs. In solar water pumping system, the pump is driven by motor run by solar electricity instead of conventional electricity drawn from utility grid. A solar photovoltaic water pumping system consists of a photovoltaic array mounted on a stand and a motor-pump set compatible with the photovoltaic array. It converts the solar energy into electricity, which is used for running the motor pump set. The pumping system draws water from the open well, bore well, streams, ponds, canal etc. The solar PV water pumping system schematic is shown in the **Fig. 3**.

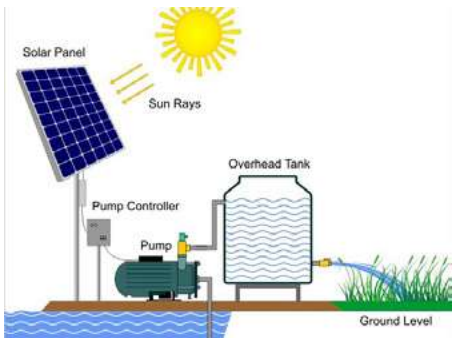

Fig. 3 Solar PV water pumping system

Solar Cooking Technology

Solar cooker is a device which uses solar energy for cooking and thus saving petroleum resources (LPG & Kerosene), fuel wood, and electrical energy to a large extent. It is a simple cooking unit, ideal to domestic cooking during most of the year except during the monsoon seasons, cloudy days and winter months. There are different types of solar cookers are available in world wide. The box type solar cooker is most popular. The box type solar cookers with a single reflecting mirror are the most popular in India. It works as an airtight box with double glass covers. A reflector is placed over it for boosting the solar radiation thus its temperature increases. Box type solar cookers are capable for cooking different types of food including rice, vegetables, pulses, chicken and fish, etc. A family size box type solar cooker is sufficient for 4 to 5 members and save about 3 to 4 cylinders of LPG every year. The life of this solar cooker is up to 15 years. The box type solar cooker is shown in **Fig. 4**.

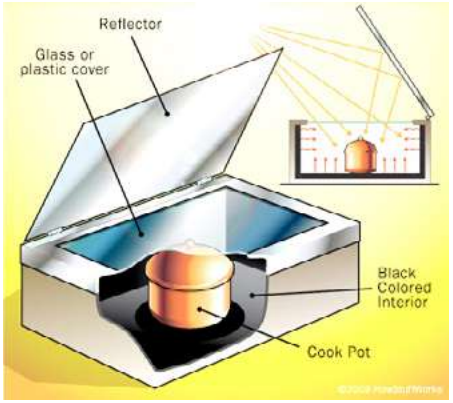

Fig. 4 Box type solar cooker

Bio-Energy Conversion Technologies

Bio-energy comprises different forms of usable energy obtained from materials referred to as biomass. Bio-energy consists of solid, liquid, or gaseous fuels. A biomass is a biological material in solid, liquid or gaseous form that has stored sunlight in the form of chemical energy. Several types of biomass can be used, with the proper technology and equipment, to produce energy. The most commonly used type of biomass is wood, either round wood or wood waste from industrial

ISSN : 2279-0454
October - December, 2019

activities. Wood and wood waste can be combusted to produce heat used for industrial purposes, for space and water heating, or to produce steam for electricity generation. Through anaerobic digestion, methane can be produced from solid landfill waste or other biomass materials such as sewage, manure and agricultural waste. Sugars can be extracted from agricultural crops and, through distillation, alcohols can be produced for use as transportation fuels. As well, numerous other technologies exist or are being developed to take advantage of other biomass feedstock.

Energy Efficient Improved Biomass Cook Stoves

Energy for cooking is a basic necessity. This is largely provided by fuel wood. In India, about 90% of households in rural areas, 75% in the semi urban areas and 25% in the urban areas use firewood stoves. Mostly villagers cook their food on traditional cook stove, which is installed by beneficiaries by placing three stones. There is no provision for smoke emission in these traditional cook stoves. The traditional cook stoves commonly used at present, have low thermal efficiency, only about 7 to 10% of the potential energy in wood is utilized in the cooking process and consequently consume more fuel. Improved biomass cook stoves are designed to clean up combustion, the hot gases can be forced to contact the pot, increasing efficiency without increasing harmful emissions. Such stoves save wood and reduce smoke. Improved stove is quicker to start, needs little tending and can meet the specific needs of a cook. Double Pot Energy Efficient Improved Biomass Cook Stove was designed and developed for hilly regions where small utensils are used for cooking (**Fig. 5**). The average thermal efficiency of these double pot energy efficient improved biomass cook stoves were observed as 28.65%, which is within the range of values of thermal efficiency of several similar works all over the world. The thermal efficiency of the double pot energy efficient improved cook stove was about 200% more than that of the traditional biomass cook stove. Thus, the use of the double pot energy efficient improved biomass cook stoves will conserve the biomass and fuel wood.

Fig. 5 Energy efficient double pot improved biomass cook stove

Biogas Technology

Biogas is a combustible gaseous fuel that is collected from the microbial degradation of organic matter in anaerobic conditions. Biogas is principally a mixture of methane (CH_4) and carbon dioxide (CO_2) along with other trace gases. Biogas can be collected from landfills, covered lagoons, or enclosed tanks called anaerobic digesters. The biogas typically has 60% methane and 35% carbon dioxide. There is also some percentage of hydrogen, nitrogen, oxygen, ammonia, moisture etc. Biogas is commonly made from animal slurry, sludge settled from wastewater and at landfills containing organic wastes. However, biogas can also be made from almost any organic waste has the ability to produce biogas: human excreta, slurry, animal slurry, fruit and vegetable waste, slaughterhouse waste, meat packing waste, dairy factory waste, brewery and distillery waste, etc. Fiber rich wastes like wood, leaves, etc. make poor feed stocks for digesters as they are difficult to digest. Many waste waters contain organic compounds that may be converted to biogas including municipal waste water, food processing wastewater and many industrial wastewaters. Solid and semi-solid materials that include plant or animal matter can be converted to biogas.

The types of biogas plant designs popular are: floating drum type, fixed dome-type and bag-type portable digester. The fixed-dome type biogas plant has become more popular across Asia. The schematic diagram of fixed dome type biogas plant is shown in the **Fig. 6**.

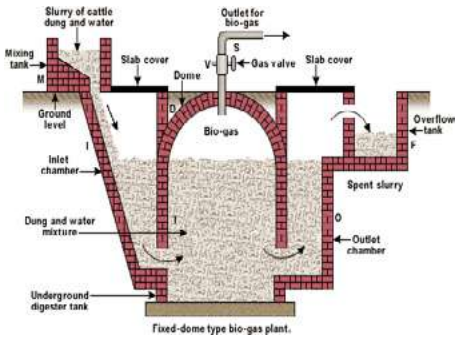

Fig. 6 Fixed dome type biogas plant

Conclusion

Renewable energy technologies produce sustainable and clean energy from different renewable energy sources. Renewable energy technologies can be widely applied in the farm for sustainable agriculture. Renewable energy technologies are considered as clean sources of energy and optimal use of these resources minimize environmental impacts, produce minimum secondary wastes and are sustainable based on current and future economic and social societal needs.

ISSN : 2279-0454
October - December, 2019

5

OPTIONS FOR ENHANCEMENT OF FARMERS' INCOME THROUGH SUSTAINABLE AGRICULTURE IN MIZORAM

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Sustainable agriculture means a system of farming which aims to produce sufficient food for present generation without deteriorating environment for the future generation. Sustainable agriculture is designed with the intention of preserving the environment, expanding the earth's natural resources, all while creating a quality of life for animals and humans. Sustainable agricultural practices are intended to protect the environment, expand the Earth's natural resource base, and maintain and improve soil fertility. Healthy soil leads to healthier plants and animals, resulting in much more nutritious food for people.

Mizoram falls under the Indo-Burma biodiversity hotspot and the landscape is dominated by relentless belt of north-south trending rolling hills (>95% of total geographical area) with some fragmented valleys. The state extends from 21° 58' to 24° 35N and from 92° 15' to 93° 29' E with a geographical area of 2108.7 thousand ha along with the altitudes varying from 30 to 2290 m from mean sea level (MSL). The population of Mizoram according to the 2011 Census is 1,097,206 with a density of 52 persons km^{-2}. Agriculture being traditionally a subsistence profession in Mizoram, the dependency on the seasonal rainfall for agriculture is very high. Most of the farming system is under rainfed shifting agriculture. Although, traditional shifting cultivation being continued, the area has abruptly decreased and switch over to other land use systems like arecanut and other plantations. Out of the rice requirement, the state produces only about 35% of its total requirement which calls for adoption of scientific technology and high yielding verities. The self-sufficiency in food grain production are yet to achieve due to lower agricultural productivity resulting from moderate to steep slopes, erratic rainfall, high degree of soil erosion, shallow soil depth and inaccessible terrain.

Potential Contributions To Farmers' Income By Sustainable Approaches

Introduction of high yielding varieties

Evaluation of lowland rice varieties under Mizoram condition showed that Gomati gave the highest grain yield of 4.83 t ha^{-1} followed by Shasarang (4.53 t ha^{-1}) and CAU- R1 (4.5 t ha^{-1}). Gomati, a medium maturing (125-130 days), performed exceedingly good in 4 districts of Mizoram, i.e. Kolasib, Lunglei, Serchhip and Champhai.

Three varieties of maize, *viz*., HQPM series, KNMH-408710 and DHM-849 performed significantly better with grain yield of 6.05 t ha^{-1}, 5.16 t ha^{-1} and 4.84 t ha^{-1}, respectively.

Seven varieties of soybean were evaluated for second crop after maize (First week of August planting). Maximum numbers of pods $plant^{-1}$ (78.50) was recorded in JS-355 variety with maximum grain yield of 18.25 q ha^{-1}. Thus, soybean can be successfully grown after maize in hill slopes and valleys for protein and oil source.

Three varieties of rapeseed-mustard *viz*., M-27, NPJ-113 and P-27 were evaluated under zero tillage. Among the varieties, NPJ-113 recorded a significant higher grain

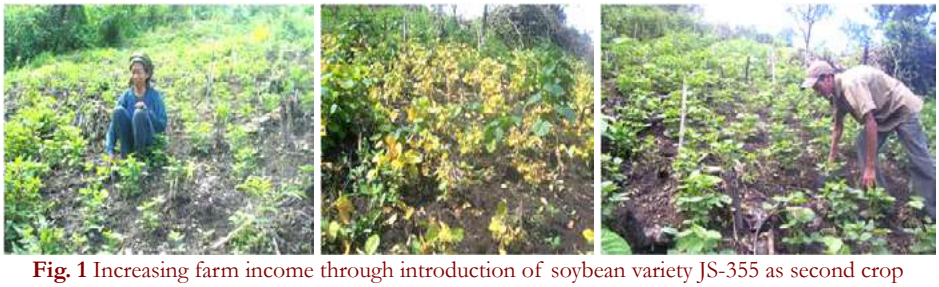

Fig. 1 Increasing farm income through introduction of soybean variety JS-355 as second crop

ISSN : 2279-0454
October - December, 2019

yield in tune of (10.91 q ha^{-1}), followed by M-27 (9.41 q ha^{-1}) and P-27 (8.24 q ha^{-1}) as compared to local variety (4.32 q ha^{-1}). M-27 because of its high tolerant to water stress is suitable for rainfed areas whereas NPJ-113 and P-27 are suitable for areas where at least two life saving irrigation facilities is available. Three hundred (300) farmers in two districts of Mizoram enhanced their income by getting average net return of Rs. 25,000 ha^{-1} within 105 to 110 days with a low investment of Rs. 8500 ha^{-1}. Motivated by the success of the technology, altogether 450 farmers across 10 villages in 5 districts adopted this technology and the area coverage under zero cultivation of rapeseed-mustard increased to 200 ha during *Rabi* 2015.

Similarly, lentil and pulses like pea can be successfully grown during rabi season. Four lentil cultivars were tested under zero-tillage condition in ICAR, Kolasib farm and also in farmers' field. The highest seed yield was recorded in DPL 62 (13.5 q ha^{-1}) followed by IPL 81 (13.3 q ha^{-1}) and IPL 15 (13.2 q ha^{-1}). Six varieties of pea were also evaluated for yield potential under zero tillage condition. Among all varieties/lines, highest seed yield was recorded in VL 42 (23.3 q ha^{-1}) followed by HUDP 15 (22.9 q ha^{-1}) and IPF 1-22 (22.3 q ha^{-1}). During 2013-16 rabi seasons, FLD was organized in 50 ha area 30 ha under pea variety HUDP15 and 20 ha under lentil variety DPL 62 in Kolasib and Champhai districts under TSP pulses.

Resource conservation trials in rice fallows to utilized soil residual moisture, and plant biomass, conservation cultivation or resource conservation (RC) system of cultivation is a viable option. The system involves utilization of additional plant biomass or the left over biomass and moisture retain in the soil and minimum disturbance to soil. Demonstration was done in three districts (Kolasib, Champhai and Serchhip) for tomato, pea and mustard. Results revealed that the yield of straw mulch were better and has higher B:C ratio than without mulch.

Fig. 2 Increasing farm income through zero-tillage lentil and pea cultivation in rice fallows

Horticulture

Dragon fruit is a healthy fruit possessing medicinal properties and is a recently cultivated fruit with important nutritional properties that has been commercialized and consumed in many parts of the world. Dragon fruit started fruiting from 14-16 months after planting and fruits are ready for harvesting in 30-35 days after flowering with an average fruit weight of 300-350 g. The market price of dragon fruit is Rs. 250-300 kg^{-1}. Dragon fruit give continuous economic yield up to 20-25 years after establishment of orchard. Cultivation of dragon fruit improves socio-economic condition of the farmers and also doubled the farmers' income.

Turmeric is an important commercial spice crop grown in Mizoram with a maximum yield recorded for RCT-1 (298 q ha^{-1}), followed by BSR-2 (288 q ha^{-1}), IISR Kedaram (276 q ha^{-1}). Cucurmin content was found to be highest for RCT-1 (6.02 %). Field level demonstration of RCT-1 was conducted in 15 ha area in Kolasib, Aizawl and Saiha districts for popularizing the variety in collaboration with KVKs and District Horticulture Offices.

Rabi vegetables are a very economic generating approach in the valleys as well as jhum fallows especially with jalkund facility. Results from farmers' trial, Garden pea (Arkel), cabbage (Rare ball), carrot (Pusa Meghali), coriander (Ramses) and Chinese mustard performed exceedingly well as compared to other *Rabi* crops. An additional net income of Rs. 8000-10,000/- per household can be generated. Similarly, HYVs of kharif vegetables *viz*., okra (Arka Anamika), brinjal (Pusa Kranti), bittergourd, pumpkin (Arka Surjamukhi), cowpea (Pusa Komal), French bean (Zorin bean), coriander (Ramses), chillies (IC- 590587), amaranthus, etc. were demonstrated in 40 ha area. HYVs of okra, cowpea, brinjal and bittergourd were highly preferred by the households because of higher productivity (30% more than local) and income.

Root and tuber crops, including cassava, sweet potato, potato and yam have good performance in jhum fallows. Cassava variety SreeVijaya; elephant foot yam (cv. Gajendra) and colocasia (cv. Mukta Keshi) were evaluated and found to give a good average yield of 34.5 t ha^{-1}. Similarly, elephant foot yam recorded a

ISSN : 2279-0454
October - December, 2019

Fig. 3 Increasing farmers' income through introduction of HYVs of tuber crops

yield of 65.23 t ha^{-1} while colocasia recorded a yield of 27.5 t ha^{-1} and 24.74 t ha^{-1}, respectively.

Strawberry is found to be one of the promising crops in the state. Two cultivars of strawberry, *viz.*, Sweet Charlie and Festival were evaluated for yield performance at Kolasib and NAIP cluster village, Saiha. Although, Festival variety (5.2 kg plant^{-1}) was found to be more superior to Sweet Charlie (4.1 kg plant^{-1}) in terms of productivity, the farmers in Saiha district preferred the later because of its sweet taste.

Flowers such as Lilium is promising, results from 10 varieties of lilium showed that 4 varieties, *viz.* Siberia, Sorbone, Dazzle and Signature performed outstanding in terms of quality and market value. Field level demonstrations were conducted during 2014-2016 at five villages; *viz.*, Khuangpuilam, Vengther, Baulpui, Hmar Veng and Tumpui in Kolasib district, Mizoram with five women SHGs under Tribal Sub Plan (TSP).

Fishery and Livestock

Besides crop husbandry, animal and fishery as a sole or integrated manner can generate income for the farmer. Poultry farming is unique and traditional custom of the Mizo people. Dual purpose poultry breeds, viz. Gramapriya, Vanaraja, Giriraja and Mizo local were evaluated for its productivity in backyard condition. Vanaraja was found to be the best breed with average age at first laying of 22-22 weeks with a body weight of 2.75 kg for female and 3.50 kg for male and the average annual egg production was 140-152 eggs while the local birds produced only 60-70 eggs annually with average body weight of 1-1.2 kg.

Mizo local pigs (Zovawk) produce less meat, litter size, etc. as compared to Hampshire crossbred pig reared in farmer's field. Crossbred pigs had lower age at 1st farrowing and farrowing interval, higher growth during pre and post-weaning, higher litter size and weight at birth and weaning, low mortality during pre and post-weaning period (6 weeks).

Pig (Hampshire cross breed) can be a viable option for integrated livestock-fish culture at the rate 30 pigs ha^{-1} water area. Similarly, ducks (Khaki Campbell breed) can also be integrated at the rate of 300 ha^{-1} water area. After one-month-old ducklings were stocked in the house, they were released into the pond for about 8–10 h day^{-1}. The fish species combination and ratio was Catla *(Catla catla)*-25, Silver Carp (*Hypophthalmichthys molitrix*) -25, Grass carp (*Ctenopharyngodon idella*) -20, Common Carp (*Cyprinus carpio* L.) -20, and Mrigal *(Cirrhinus mrigala)*-10. The fresh manure contribution from a single pig and duck for feeding fish was 1200 and 6 kg, respectively. The quantity of N, P and K added to the fish pond by recycling the animal manure were approximately 4.5, 3.5 and 3.0 kg, respectively by a single pig. The corresponding values by for a single duck were 0.02, 0.01 and 0.01 kg, respectively.

Fig. 4 Increasing farmers' income through strawberry cultivation

ISSN : 2279-0454
October - December, 2019

6

FALL ARMYWORM, *SPODOPTERA FRUGIPERDA* (J. E. SMITH) AND ITS MANAGEMENT THROUGH BIOLOGICAL CONTROL

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The fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (FAW) is native to North and south America and it was first recorded in African continent in 2016 then subsequently spread very quickly across Asia causing severe damage to cereal crops. It is a voracious feeder. In India, it was first reported in 2018 on Maize and now has spread to 20 states. In 2019, the entire maize growing areas of North-Eastern region were affected by this pest. Severe incidence of FAW has also been observed in Mizoram, Nagaland, Tripura, Manipur and adjoining states on maize crop. In April 2019, the pest was first detected in Manipur by the entomologists of ICAR Research Complex for NEH region, Manipur Centre. Out of 1053 of maize growing villages in Manipur, 748 villages were found to be infested by FAW; the pest caused damage to the maize crop at an average of 10-100% at standing crop. This year, the biggest victims so far have been farmers in the northeastern states, where a cumulative of 10,772 hectares of maize crop has been affected. The pest has also spread to Uttar Pradesh in the north, Gujarat in the west, Chhattisgarh in central India, and several states in the south. It is known to attack at least 80 different crop plants with preference towards cereals, especially maize. In African countries producing maize, the value of these losses is estimated to be ~2.48 - 6.19 billion USD. In 2016, 25.9 million metric tons of maize was produced in India. In 2017, that number rose to 28.7 million tons. In 2018, however, production fell by 3.2% to 27.8 million tons. It is expected that the net production will decline further in 2019 due to the pest attack. Application of broad spectrum insecticide may lead to resistance against this pest and may disrupt integrated pest management (IPM) tactics. Biological control is an eco friendly method and as a part of IPM provides an economically and environmentally alternative to synthetic insecticides for managing this pest. A lot of natural enemies have been reported for this pest in the Americas and Caribbean basin. Thus efforts should be made to search native natural enemies and their proper use to manage this pest.

Host Range

FAW has a wide host range of approximately more than 100 recorded plant species in 27 families. It prefers plants from gramineae family such as maize, millet, sorghum, sugarcane, rice, wheat, etc. There are reports on its infestation on other field crops like cowpea, groundnut, potato, soybean, cotton, etc.

Life Cycle And Nature of Damage

The male and females complete their lifecycle in 32-43 and 34-46 days, respectively at 26±20C, 75 to 80% RH and L12: D12 photoperiod. Depending on the appearance of the migrating adults and climate, FAW can have up to eight generations per year in maize fields in tropical areas.

Eggs are laid in masses of approximately 100-200 dome shaped eggs. A female (**Fig. 1**) can produce 1500-1700 eggs during its lifespan. Eggs of FAW are usually covered with white scales from the female abdomen. Eggs are hatched within 2 to 3 days. It has six larval instars. After hatching, neonates start feeding on leaves by scraping and skeletonizing the upper epidermis causing a characteristic 'windowing' effect. Later instars enter into the whorl (**Fig. 2**) and start feeding between the leaves leaving sawdust-like frass which can be an easily spotted sign of larval feeding (Figure 3). Larger larvae are cannibalistic and nocturnal in nature. Larval period varies from 14-21 days and pupal period is 9-16 days. The larva of FAW can be identified by four characteristic spots on the second to last segment, forming a square or rectangle. Moreover, the frons of head of the matured larva has an inverted "Y" mark.

ISSN : 2279-0454
October - December, 2019

Fig. 1 Adult

Fig. 2 Adult inside whorl

Fig. 3 Larva inside whorl

Fig. 4 Parasitized egg mass

Biological Control of FAW

Many parasitoids, predators and pathogens have been recorded from FAW from different part of the country. In recent surveys, egg parasitoids like *Trichogramma* sp., *Telenomus* sp.; egg-larval parasitoid, *Chelonus* sp.; larval parasitoids like *Campoletis chlorideae* were found parasitizing different stages of FAW. Besides these parasitoids, larval-pupal parasitoid and tachinid parasitoids were also observed. Several predators like *Eocanthecona* sp., *Forficula* sp. were found to predate FAW larvae. Beside these, epizootic of *Metarhizium* (*Nomuraea) rileyi* was also observed in field. Other biocontrol agents include entomopathogenic nematodes which can also be used to control larvae.

Among natural enemies, egg parasitoids belonging to *Trichogramma* and *Telenomus* are widely used to manage FAW damage in North and South America. These parasitoids can easily be multiplied in laboratory on natural or factitious hosts. In Latin America, inundative releases of *T. remus* in maize fields showed 90% parasitism, providing full control of FAW. Similarly, a preliminary IPM field experiment undertaken by ICAR-NBAIR at Chikballapur, Karnataka found that augmentative releases of *T. remus* and *T. pretiosum* effectively controlled the damage caused by FAW as compared to the control. This shows the potential of egg parasitoids for FAW management.

An IPM trial was conducted by ICAR-NBAIR to manage FAW in maize including pheromone traps; release of egg parasitoids viz. *Telenomus remus* and *Trichogramma pretiosum* at weekly interval from 20 days old crop onwards; neem oil; *Bt* spray and entomopathogenic fungus (*Beauveria bassiana* and *Metarhizium anisopliae*). It was found that 98% decrease in egg mass at 80 DAT as compared to 8.5% decrease in farmer's practice. Similarly, larval population was also decreased by 79.16% in IPM field compared to farmer's practice where only 12.5% reduction was observed. In IPM field percent parasitism by *Trichogramma* sp. varied from 8.19-18.25 (**Fig. 4**).

In Manipur condition, ICAR Manipur Centre farmers whose fields were already 70% damaged or more on first pest detection suffered the most. However, observant farmers whoever detected during early infestation could save their crop and prevent economic loss. ICAR Manipur Centre recommended both *Beauveria bassiana* (cfu 1 x 10^{11}) @ 3-5 ml l^{-1} water for foliar spray and *Metarhizium anisopliae* (cfu 1 x 10^{11}) for root zone spray @ 3-5 ml l^{-1} water at an interval of 5 days to manage FAW in mazie field at Khurkhul village (Imphal West District). Both the fungi were found effective for the management of many other insect pests on different crops however yet untried on FAW. According to the farmer, the two biopesticides controlled the pest very effectively and she could find many diseased caterpillars on the maize plants (**Fig. 6**).

Conclusion

In India, we have *Telenomus remus*, *Trichogramma chilonis* and *T. pretiosum*. It is very essential to utilize them properly to target the egg stage of this pest. Further, entomopathogenic fungi, virus, bacteria and nematodes can be used for managing larval stage. Pheromone traps can also be used to monitor this pest and it is easily available in market. Thus it is clearly evident that biocontrol has potential to manage this pest both in egg and larval stages provided with timely interventions.

Fig. 5 Maize crop damaged by FAW

Fig. 6 Spraying biopesticides in the field, diseased larvae caught after spray

ISSN : 2279-0454
October - December, 2019

7

INSECT PESTS OF CITRUS AND THEIR MANAGEMENT

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Citrus is one of the most important fruits and one of the largest fruit industries in the world, grown in more than 52 countries around the world. Brazil and China are the largest producers of citrus worldwide producing about 45 million tons (MT) of citrus fruit together, followed by USA, India, Mexico and Spain with a production of 10.7, 8.6, 7.2 and 5.5 MT, respectively (Mahmood *et al.* 2014).

India ranks fourth in the production of citrus fruit in the world. Citrus fruits originated in the tropical and sub tropical regions of South East Asia, particularly India and China.

In India, citrus is commercially grown in about 10.42 lakh ha with an annual production of 100.90 lakh tonnes and productivity of 9.7 t ha^{-1} (NHB, 2013) and are primarily grown in Maharastra, Andhra Pradesh, Punjab, Karnataka, Uttaranchal, Bihar, Orissa, Assam and Gujarat It is of Particular interest because of its high content of Vitamin C and refreshing juice. Of the various types of citrus fruits grown in India, orange (mandarin or santra), sweet orange (mosambi) and lime/ lemon are of commercial importance.

North-Eastern Region is one of the richest reservoirs of genetic diversity of Citrus as the primary as well as the secondary centre of origin of numerous citrus species and has been described as one of the major centre of diversity for citrus in both wild and cultivated forms (Singh *et al.*, 2006).

North-Eastern Region Systematic exploratory survey of mandarin orange showed that *Citrus indica* is one of the most primitive species of citrus available in the region. Other promising natives so far identified and commercialized are cytron (*C. medica*), sweet lime (*C. lamittoides*), sour orange (*C. aurantium*), sweet pumalo (*C. grandis*), sour pumelo (*C. megaloxycarpa*), Khasi paida (*C. latipes*), rough lemon (*C. jambhiri*), etc. High rain fall, prolong high humid conditions with favourable temperature regime and cultivation and / or occurrence of a number of wild and cultivated species of citrus harbour largest number of pest and diseases of Citrus in this region. In India, 250 species of insects and mites have been reported infesting different species of citrus (Wadhi and Batra, 1964).

The trunk borer, *Anoplophora versteegi*, Citrus psylla, *Diaphorina citri* and black aphids (*Toxoptera aurantii* and *T. citricidus*) are major pests of citrus. In NE region. Leaf miner, *Phyllocnistis citrella* is also equally important and damages at nursery and plants during each new flush. Other pests of economic importance includes lemon butterfly, leaf mining beetles, tobacco caterpillars, leaf folder, looper, mealy bugs, scales, orange shoot borer, bark eating caterpillar, fruit sucking moths and fruit flies etc. (Thakur *et al*, 2012).

Major insect pests of citrus

Around 250 species of insects are reported.

Regular pests

Trunk borer (*Anoplophora versteegi*)

Bark eating caterpillar (*Inderbella* spp.)

Leaf miner (*Phyllocnistis citrella*)

Lemon butterfly (*Papilo domelis*)

Citrus psylla (*Diaphornia citrii*)

Citrus aphid (*Toxoptera citricida)*

Emerging pests

Citrus looper (*Anacamptodes fragilaria)*

Citrus mealy bug (*Planococcus citri)*

Citrus black fly (*Aleurocanthus woglumi*)

Fruit sucking moth (*Ophederes* sp., *Achaea janata*)

ISSN : 2279-0454
October - December, 2019

Nature of damage of major insect pest of citrus

Citrus Trunk Borer (*Anoplophora versteegi)*

- Grub bores into the pith making round holes generally at the base of the trunk.
- Accumulation of coarse saw dust in tree base.
- Grub destroys the xylem & phloem during their long development period causing the deterioration of the tree resulting in serious economic losses.
- About 15 - 60% damage caused in citrus of Assam and even as high as 68% damage in Khasi mandarin.

Bark Eating Caterpillar

- Infest bark of young and matured citrus plant.
- Larvae make tunnel at the joints of trunk or branches and feed on the bark during night.
- Heavy infestation leads to slowly drying of plant due to nutrient deficiency.
- Attacked tree gradually declines.

Citrus Butterfly

- Citrus butterfly is a pest of nurseries and young plantations.
- Caterpillar feeds on foliage causing defoliation. At times young plants are completely defoliated.
- Most destructive stage is larva. Young larval stage looks like bird excreta

Leaf miner (*Phyllocnistis citrella*)

- Mostly important in nursery and young orchard.
- Larval stage is more destructive. Newly emerged larva mines the under surface of the leaf in a zigzag way.
- Appearance of silvery serpentine mines on the underside of leaf which leads to wrinkling and curling up.
- Leaf miner attacks helps in spreading mealy bug infestation & predisposes to Canker infection.

Citrus Psylla (*Diaphornia citrii*)

- Peak period for multiplication is in May.
- Both nymph & adult sucks the cell sap from newly emerged leaves, tender shoots and flowers causing curling of leaves & defoliation leading to deblossoming and dieback.
- Secretes whitish crystalline honeydew which attracts the growth of fungus, adversely affecting the photosynthesis.
- Psylla is also known to inject toxin in plant due to which die-back of shoot occurs.
- It acts as vector of citrus greening virus disease.

Citrus looper (*Anacamptodes fragilaria*)

- Drooping & hanging from trees/ upper branch through silken threads.
- Looper larva voraciously consume new growth flushes resulting in severe defoliation, but also feed on blossoms and young fruits.
- Very young larvae typically feed on lower leaf surfaces along the leaf margin.
- Mature larvae eat the leaves making holes on it or consume them entirely. It is an emerging pest.

Citrus Aphid (Black Aphid: *Toxoptera aurantii*, Brown Aphid: *Toxoptera citricida*) & Mealy bug (*Planococcus citri*)

- Nymph and adult suck the sap from tender parts of plant and devitalize.
- Nymphs excrete honeydew on which black sooty mould grows wildly resulting in blackening of the twig.
- In severe infestation the flowers do not form fruits.
- Brown citrus aphid (*Toxoptera citricida*) is responsible for vectoring citrus virus disease 'Tristeza'

Citrus Black fly (*Aleurocanthus woglumi*)

- The cell sap is suck from the leaves leading to leaf curling, leaves fall off immaturely.
- Honey dew secretion leads to sooty mould fungus.
- Leaf turns to black in colour and affects photosynthetic activity of the leaves.
- Affected trees produce few blossoms which develop into insipid fruits.

Fruit Sucking Moth (*Ophederes* sp. *Achaea janata*)

- It is a serious pest of maturing khasi mandarin fruits.
- Adult is the damaging stage.
- The adults puncture the ripening fruits.
- Such fruits drop prematurely, As a result of rottening due to fungal and bacterial infections introduced through punctures causing considerable fruit loss.

Citrus psylla (*Diaphorina Citri*)

Among the insects pests, which infest and cause heavy losses to the citrus, citrus psylla *Diaphorina citri* is the most destructive and consequently the most important of all the insect pests of citrus. Citrus psylla is also a vector of a (*Citrus tristeza colesterovirus*), which is responsible for the greening disease of citrus (Su *et al.*, 1991).

ISSN : 2279-0454
October - December, 2019

Population of citrus psylla showed two peak times in a year, firstly in the month of August and 2nd time in the month of April. Correlation values showed that environmental factors had almost no effect on the population build up of citrus psylla.

Three insecticides, methamidophos, dimethoate and imidacloprid applied, had almost equal effect on the population reduction of citrus psylla on all the three species of the citrus.

Citrus die back

The term die back means death of plant from top to down wards. Citrus dieback is not a specific disorder but is culmination of several interacting factors such as pathological infections, pest attack, nutritional disorder, unfavourable environment, faulty cultural practices, poor choice of planting material etc.

- Avoid spraying during strong wind, cloudy days and dizzling
- Spray may be given as soon as the new flush is emerged.
- Destroy the ant colonies .
- Close spacing and water logging conditions should be avoided.
- Avoid pruning during the active growth periods, if necessary, prune only the infected dry shoots after fruit harvest.
- Apply N-ous fertilizer as the need only.
- Modify canopy structure in such a way that light interception is maximum below the canopy.

Integrated Pest Management practices for Citrus

- Conditions that lead to stress on plants should be avoided such as close planting and water logging.
- Good orchard sanitation & removal of weed.
- The affected plant parts should be pruned and destroyed.
- Excessive use of nitrogenous fertilizer and irrigation should be avoided.
- Need base application of insecticides) for management of insect pests based on ETL.
- Use and conservation of predators/parasitoids.
- Field release of predatory ladybird beetle, *Cryptoleamus montrouzieri* @ 10 beetles plant^{-1} and inoculative release of exotic parasite, *Leptomastrix dactylopii* is very effective.
- For management of bark eating caterpillar, citrus trunk borer and many other diseases, application of Bordeaux paste during March-April & September-October on the tree trunk up to the height of 1m is very effective.

Suggested ITK for citrus pest management

Smoking in the field	Control of fruit fly	Smoke often act as repellent
Application of fish water at the base of the citrus plant	Control of citrus trunk borer	The fish water attract predatory red tree ant (*Oecophylla* sp)
Smoking below the citrus plant before flowering	Control of citrus pests	Smoke repel insect pests
Placing of red tree ant (*Oecophylla smoragina*) nest on the citrus plant	Control of citrus pests	Red tree ant is a predator of citrus pest

(Source: Deka *et al.*, 2005)

Technology for Rejuvenation of Declining Orange Orchards

Causal Factors

The intensity of factors responsible for citrus decline may vary from orchard to orchards and region to region in the state but the main factors responsible for the decline were found as follows:

1. No effective control against insect pests, especially against the rampant attack of Trunk borer and Bark eating caterpillar.
2. Insufficient control of diseases, especially against Twig blight, Phytophthora foot rot and Stem end rot.
3. No control against parasitic plants like Loranthus etc, and epiphytic plants like Mosses, Lichens, Orchids etc.
4. No use on amendments in acidic soils.
5. Malnutrition of major and minor elements specially P, Ca, Mg, Zn, B, and Mo.
6. Long and heavy spells of rainfall (upto 6 to 7 months).
7. Heavy soil erosion due to cultivation up to 60-70^0 slopes in the hills region and also deforestation.
8. Water logging in the plain region due to lake of proper drainage system and also in some orchards due to rise of river bed present near to orchards.
9. Plantation of non descript seedlings of unknown yield potential and tolerance to pests and diseases attack.
10. Plantation without cultivation and no control of weeds.

11. Rain fed cultivation, as a result there is long spell of water stress condition during winter.
12. General neglect due to causes of ledge system of marketing.
13. In certain cases, over bearing during 'on' year that often set the initial stage of decline.
14. Cultivation in unsuitable soils.
15. Excess shade and also keeping tree inside the orchards having allolopathic effect may sometime cause citrus decline

Rejuvenation schedule

Based on diagnosis of the causes of decline, the rejuvenation schedule was formulated with multi-disciplinary approach. Rejuvenation programme should be started after harvesting the fruit during winter season and before new flush emergence. The following operations should be carried in declining orchards.

Pruning and training: Unwanted, diseased and pest infected branches and twigs is to be removed by pruning and training in the month of December and January after harvest of the fruits. At the same time, all the parasitic and non-parasitic plants *viz.* loranthus, mosses, orchid etc. are to be removed properly**.**

Correction of soil pH : Agricultural lime @ 1 kg plant^{-1} is to be applied to the soil surrounding the plant and is to be mixed with soil by light hoeing in the month of January and February

Integrated nutrient management: Apply 450 g N + 225 g P_2O_5 + 450 g K_2O + 5.625 kg Neem Oil Cake along with VAM (500 g), PSB (100 g), Azospyrillum (100 g) and *T. harzianum* (100 g) plant^{-1} year^{-1} in two splits i.e., in March-April and September - October was found to best. The required amount of biofertilizers is to be mixed together with 10 kg FYM and applied 15 days before the application of inorganic NPK. Two foliar sprays of micronutrient consisting of 0.2% Zn, 0.05% B and 0.05% Mo are to be applied; first spray in the month of March - April and second spray during September-October. Integrated management of trunk borer and bark eating caterpillar:

Prophylactic smearing of 50 ml Dimethoate + 1 kg lime in 10 liters water along with gum at the tree trunk up to 1 metre height from the ground level during March – April prevents early infestation of both trunk borer and bark eating caterpillar. Cleaning of infected holes and insertion of cotton soaked in Petrol followed by mud plastering will have to be done where and when the trunk borer attack is noticed.

Management of major insect pests of Citrus

Citrus psylla

a) Monitoring using yellow sticky trap.

b) Chemical control using dimethoate @ 1.25 ml or imidachloprid @ 0.3 ml or quinalphos @ 1.0 ml or acephate @ 1g or thiometan 0.8 ml at bud burst stage. Second spray should follow after 10-15 days.

c) Extracts of botanicals like *Vitex nigundo*, *Acorus calamus,* etc. can also be used.

d) Biological control: Predators like *Mallada boninensis* Okamoto and *Cheilomenes sexmaculata* (Fabricius) and host specific parasitoid, *Tamarixia radiata* (Waterston) are effective in bringing down the psylla population.

Lemon butterfly

(i) Collection of infested leaves and destroying by burning or burying under the soil.

(ii) Hand-picking and destruction of the various stages of the butterflies,

(iii) Severe infestations can be controlled by spraying leaves with Malathion 57 EC or Dimethoate 40 EC at the rate of 2.0 ml l^{-1} of water.

Citrus leaf miner

(i) For effective control, prune heavily the affected parts during winter and burn the same

(ii) Plants with new flushes of leaves should be sprayed with Dimethoate 40 EC or Carbosulfan 20 EC or Malathion 57 EC @ 2.0 ml l^{-1} of water. A second spraying should be given after 15 days of the first spraying.

Citrus mealy bug

(i) Collection and destruction of affected leaves and twigs, (ii) severely infested plants may be sprayed with Malathion 57 EC or Diazinon 60 EC @ 1.0 ml l^{-1} of water.

Orange fruit fly

(i) Regular removal and destruction of fallen and infested fruits can reduce the pest population

(ii) Male annihilation, utilizing the attraction of males to methyl eugenol may be used to eradicate the pest, (iii) application of bait spray containing Malathion 57 EC and sugar in water will also reduce fruit fly infestation, (iv) after harvest dipping of fruits in 5 per cent sodium chloride solution for 60 minutes will destroy the eggs.

Thrips

(i) Spraying of the affected leaves with plain water,

(ii) In case of severe infestation 2-3 times spraying of Malathion 57 EC or Tafgor 40 EC @ 2.0 ml l^{-1} of water at 10-15 days interval.

ISSN : 2279-0454
October - December, 2019

Citrus greening diseases

Citrus greening disease was first detected in the United States in Florida in 2005. It was found throughout Asia, the Indian subcontinent and neighboring islands, the Soudi Arabian Peninsula and since 2004 in the Sao Paulo State of Brazil. The citrus greening pathogen is transmitted by psyllid vectors, grafting and possibly by citrus seed. The Chinese name, Huanglongbing, meaning yellow shoot or yellow dragon refers to the leaf yellowing that may appear on a single shoot or branch.

Mode of transmission

- Can be transmitted by bud grafting but not at high rates due to necrosis in sieve tubes and uneven distribution of the bacteria
- Dodder (*Cuscuta* spp.)
- Citrus Psyllid is the primary vector
  - Occurs with high psyllid populations when the host is flushing which is when the psyllid migrations are highest
  - The fourth and fifth instar nymphs can acquire citrus greening bacteria and transmit the disease as nymphs or adults

Insect vector

2 species of Citrus psyllid are vectors

- The African Citrus Psyllid, *Trioza erytreae* occurs in Africa, Reunion, Yemen and vectors the African strain of greening. It survives well in cool upland areas
- The Asian Citrus Psyllid, *Diaphorina citri* is in Asia, India, Saudi Arabia, Reunion, and North, South and Central America. It is more resistant to high temperatures and survives in hot lower altitudes.

Control of Vectors

- Systemic pesticides used for psyllid control on young non-producing trees and contact pesticides used on older trees

Control of the greening pathogen

- Thermotherapy
  Treatment of bud wood, seedlings or other plant material at high temperature (i.e. 47° C for 2 hr)
- Shoot-tip grafting
- Chemotherapy
  Injection or treatment with antibiotics
- Breeding for resistance

Other suggested control measure

- Produce greening-free trees
- Use shoot-tip grafted material
- Use sticky yellow traps to identify nursery and groves that have psyllids
- Remove abandoned trees/groves and alternate host

Conclusion

Insect pests on citrus have rich natural enemy complexes and mostly are under natural control. Some of the pests such as mealy bug *Drosicha stebbinji*, fruit flies *Bactrocera* spp., butterfly, leaf miner, scale insects *Aoinidiella* spp. and citrus psylla need to be addressed on priority. All these pests too have good natural enemies complexes, however some of the agricultural practices impact on natural enemies that need to be identified. There is need to develop techniques which encourage natural control. Biological control through augmentation and conservation of parasitoids integrated with other non pesticide measures need to be tested with holistic approach in citrus.

Citrus is a perennial crop therefore all negative approaches of applying insecticides should be avoided. The pest control should be integrated rather than depending only on chemical control as most of the farmers do. Therefore pests should be monitored regularly to know their abundance and time of activity. This aids in making timely decisions and maintaining farmer's economic and environmental balances.

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October - December, 2019

8

PROSPECTS OF MECHANIZATION FOR RAPESEED AND MUSTARD CULTIVATION IN NORTH EASTERN REGION

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Rapeseed-Mustard is the important crop in the word; India is the third largest producer of rapeseed-mustard after China and Canada. Rapeseed-Mustard is one of the second largest oilseed crop in India. the crop is grown in almost 24 states for domestic use as well commercial purposes. More than 85% production of Rapeseed-mustard comes from 05 States namely Rajasthan (48%), Haryana (12%), MP (10%), UP (9%) and West Bengal (7%). Fourty six districts of Rajasthan (22), MP (6), Haryana (5), UP (2), West Bengal (6), Gujarat (3) and Assam (2) contributes >70% of total production of rapeseed and mustard in the country. The area of oilseeds in NEH region is 3.95 lakh ha with production of 2.61 lakh ha. In Sikkim the total production and yield of mustard sown and rapeseed are 6000 ha, 4500 and 0.7 q ha^{-1} respectively. To maintain the highest growth rate (31.8%) among all states the present agricultural land (11% of total area of Sikkim) needed selective farm mechanization for all cultivation operations in terraces Clod breaking operation is required to produce a granular soil structure in the final seedbed. Clod crushers, *patela* harrow, etc., are very effective for clod crushing under favourable soil moisture conditions but their effect is confined to soil surface only. Smoothening of seedbed is required for proper operation of sowing machines, better distribution of irrigation water and quick disposal of excess rainwater. Smoothening can be best achieved by using wide backward inclined blades, such as levelling boards, floats and *patela* harrow with closely spaced shallow working narrow tines. Wooden plank, *patela* harrow, are recommended for smoothening operation.

Table 1 Benefits of improved equipment package using animate power sources for mustard cultivation

Equipment/Practice	Unit price (Rs.)	Field capacity ha h^{-1} (sq.m h^{-1})	Cost of operation in improved method (Rs. ha^{-1})	Cost of operation in traditional practice (Rs. ha^{-1})	Economic benefit over traditional practice (Rs. ha^{-1})	Annual Economic benefit/ unit
Seedbed preparation						
Animal drawn improved wedge plough (200 mm)	1000	0.02 (200)	3000	4425	1425	2138
Animal drawn planker cum leveler (200 mm)	1500	0.02 (200)	1200	2870	1670	2505
Seeding operation						
Animal drawn /Two row seed drill cum planter	7500	0.05 (500)	1200	2800	1600	2400

ISSN : 2279-0454
October - December, 2019

Weeding and Interculture						
Manual Wheel hoe	350	0.01 (100)	1690	4400	2710	2265
Animal drawn three tyne cultivator	1600	0.05 (500)	1200	4200	3000	4500
Plant Protection						
Manual knapsack sprayer for bio-insecticide	1800	0.08 (800)	780	1600	820	1230
Harvesting						
Improved sickle	50	0.005 (50)	3250	6000	2750	4125
Threshing						
Plot thresher (1 hp)	25000	100 kg h^{-1}	780	1400	620	930
Total	**37000**		**12320**		**14595**	**20093**

Table 2 Power tiller based farming package benefits for mustard cultivation

Improved Equipment	Unit price (Rs)	Field capacity (ha h^{-1} sq.m h^{-1})	Improved method , cost of operation (Rs. ha^{-1})	Traditional method, cost of operation (Rs. ha^{-1})	Economic benefit over traditional practice (Rs. ha^{-1})	Annual economic benefit (Rs. $unit^{-1}$)
Power tiller operated mould board plough	5000	0.06	1225	4425	3200	8000
Power tiller operated rotavator	30000	0.10	970	4425	3455	8638
Power tiller operated seed drill cum planter	10,000	0.12	2500	4800	2300	5750
Power tiller operated sweep cultivator for weeding	4500	0.10	1650	4400	2750	6875
Manual knapsack sprayer for bio-insecticide	1800	0.08	400	1600	1200	1800
Improved sickle	70	0.005	3200	4800	1600	2400
Small power thresher	30000	110 kg h^{-1}	545	1400	855	1283
Total	**81370**				**15560**	**34746**

The package of animal based farming system having 8 equipments, in terrace condition for rapeseed and mustard cultivation resulted in economic benefit of Rs 14595 ha^{-1} and such package can provide annual economic benefit of Rs 20093. Similarly power tiller based farming system has cost of cultivation of Rs. 15560 ha^{-1} and anuual economic benefit of package based on power tiller have phave accrued benefit to the tune of Rs. 34746 for cultivation of rapeseed and mustard on terraces.

New generation are enthusiastic in cultivation using modern equipment ensuring safety and comfort therefore power tiller based farming system may attract rural youth. Such system can succeed in achieving annual economic benefit to the tune of around Rs. 35000 by adoption of package for light weight matching equipment for rapeseed and mustard production. The package cost incurred can be recoverd in 2.35 years for power tiller based farming system.

If the terrace width is lesser (<2-2.5 m) in terrace condition then animal based farming system need to be recommended for rapeseed and mustard cultivation which can provide annual economic benefit of Rs. 20000 for one package of 08 equipment. This capital cost of package can be recovered in 1.84 years for production of rapeseed and mustard cultivation.

Such packages of improved equipments are commercially available and ICAR Research complex for NEH Region, Barapani (Meghalaya), CAEPHT (CAU), Ranipool (Sikkim) and ICAR-CIAE Bhopal (MP) can be enquired for supply and repair/ operational problems/ trainings.

ISSN : 2279-0454
October - December, 2019

9

INSECT PESTS OF MAIZE AND THEIR MANAGEMENTS

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Maize (*Zea mays* L.) is one of the most versatile crop grown across the globe, including tropical, subtropical and temperate regions, from mean sea level to 3000 m above sea level. Maize is third most important cereal crop in India after rice and wheat. It is cultivated throughout the year in most of its states for various purposes that include grain, feed, fodder, green cobs, sweet corn, baby corn, popcorn, starch and industrial products. It is grown in all the three seasons – *Kharif* (rainy), *Rabi* (winter) and *Zaid* (summer). In some of the regions, spring maize (February – April/May) is also becoming popular with short duration varieties (<100 days). The productivity of maize is challenge by biotic and abiotic factor. Among the biotic factor, over 130 insect pests cause varying degree of damage from germination to harvest resulting into low yield. Among the insect pest, maize stem borer and cob borer is the major pest of maize. Bihar hairy caterpillar, termites, aphids, maize shoot bug, white grub is of minor importance. The symptoms of damage and management practice of some of the important pest are given below:

Stem borer

Causal organism: *Chilo partellus*

Symptoms of damage

- Central shoot withers and leading to "dead heart".

Fig.1 Characteristic leaf damage caused by maize stem borer

Fig. 2 Larvae mines the midrib enter the stem and feeds on the internal tissues.

- Larvae mines the midrib enter the stem and feeds on the internal tissues.
- Bore holes visible on the stem near the nodes.
- Young larva crawls and feeds on tender folded leaves causing typical "shot hole" symptom.
- Affected parts of stem may show internally tunnelling caterpillars

Management

- Mix any of the following granular insecticides with sand to make up a total quantity of 50 kg and apply in the leaf whorls on the 20th day of sowing
- Phorate 10% CG10 kg ha^{-1}
- Carbaryl 4% G 20 kg ha^{-1}
- For stem borer, release egg parasitoid *Trichogramma chilonis* @ 2,50,000 ha^{-1} coinciding egg laying period. Three releases at weekly interval are desirable. Third release is to be accompanied with larval parasitoid *Cotesia flavipes* @ 5000 ha^{-1}

ISSN : 2279-0454
October - December, 2019

- If granular insecticides are not used, spray any one of the following :
- Carbaryl 50 WP 1 kg ha^{-1} on the 20th day of sowing (500 l of spray fluid ha^{-1}).
- Dimethoate 30% EC 660 ml ha^{-1}

Termites

Causal organism: *Macrotermes* spp.

Symptoms

- Termite is also an important pest in many areas and on the damaged plants usually find earthen sheeting
- Termite damage starts soon after sowing and continues till the growing stage.
- The leaves of damaged plants droop down which later wither and dry. Such plants are easily uprooted.

Fig. 3 Symptom of damaged (Earthen Sheeting) caused by Termites

Management

- Locating termitarium, digging out queen and destroying is the only permanent remedy.
- Fumigation of ant hill with carbon disulphide or chloroform mixture
- Destruction of crop residues which form sources of infestation
- Seed treatment with chlorpyriphos @ 6 ml kg^{-1} of seed
- Soil application of chlorpyriphos 50 EC @ 10 ml l^{-1} as a soil drench at sowing time in termite prone soils.

Aphid or Plant lice

Causal organism: *Rhopalosiphum maidis*

Symptom of damage

- Yellowing of leaves
- Colonies of aphids found in central leaf whorl.

Fig. 4 Aphids colonies on maize cob and leaf

Management

- Mix any of the following granular insecticides with sand to make up a total quantity of 50 kg and apply in the leaf whorls on the 20th day of sowing
- Phorate 10% CG10 kg ha^{-1}
- Carbaryl 4% G 20 kg ha^{-1}
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- If granular insecticides are not used, spray any one of the following :
- Carbaryl 50 WP 1 kg ha^{-1} on the 20th day of sowing (500 l of spray fluid ha^{-1}).
- Dimethoate 30% EC 660 ml ha^{-1}

Maize shoot bug

Causal organism: *Peregrinus maidis*

Symptom

- Plants become unhealthy stunted and yellow.
- The leaves wither from top downwards.
- Panicle formation is inhibited and the plants die if attack is severe.
- Honeydew secreted by the bug causes growth of sooty mould on leaves.
- The midribs of the leaves turn red due to egg-laying and may dry up subsequently.

Fig. 5 Shoot bug colonies on maize leaf

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October - December, 2019

Management

Spray any following insecticides

- Diazine 0.04% or
- Dimethoate 0.02%,
- Phosphomidon @ 250 ml in 450-500 l water ha^{-1}

White Grubs

Causal organism : *Holotrichia serrata*

Nature of damaged

- Cutworms are nocturnal in habit
- Adult's feeds on the leaves and tender shoots
- Grubs feeds on the root and rootlets as a results death of the plants

Fig. 6 Grub -c- shaped scarabaeiform form larvae

Fig. 7 Roots damaged by root grubs

Management

- Collection and destruction of grown up larvae of cutworm

Bihar hairy caterpillar

Causal organism: *Spilosoma* sp.

Nature and symptom of damage

1. The newly hatched larvae feed gregariously by scraping the green matter or skeletonization on the under surface of the young leaves leaving upper epidermal layer intact
2. Later feed voraciously on the leaves leaving the petiole and midribs and main stem of the plants
3. They march from field to field in gregarious manner and affected field appear as if grazed by cattle

Fig. 8 Damaged caused by Bihar hairy caterpillar on leaf

Managements

1. Deep summer ploughing
2. Use of well rotten manures
3. Intercropping with pigeon pea at a row ratio 2:1 is effective in reducing pest attack
4. Collection and destruction of larvae
5. Spray phosalone 35EC at 1000 ml ha^{-1}

CORN EARWORM

Causal Organism: *Helicoverpa armigera*

Symptoms

- The caterpillar feed for while on silk or tender leaves and later bores the cobs feeds on milky grains at the top of the cob and also feed partially on developing grains Bored area of the cob is plugged with excreta.

Fig. 9 Cob damaged due to Helicoverpa armigera

Fig. 10 Caterpillar feed partially on developing grains and bored holes are plugged with excreta

Management

- Set up of light traps
- Set up sex pheromone traps at 12 ha^{-1}
- Two applications of NPV at 10 days interval at 1.5 $x10^{12}$ POB ha^{-1} along with Crude sugar 2.5 kg + cotton seed kernel powder 250 g on the ear heads

Apply any one of the following on 3rd and 18th day after panicle emergence:

- Carbaryl 10 D 25 kg ha^{-1}
- Malathion 5 D 25 kg ha^{-1}
- Phosalone 4 D 25 kg ha^{-1}

ISSN : 2279-0454
October - December, 2019

10

ANTIOXIDANTS: BOOM OR BANE TO PORCINE HEALTH

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Antioxidant is any vitamin, nutraceutical, mineral, or herb that protects against cellular damage from reactive oxygen species (ROS), including free radicals, single oxygen atoms and hydrogen peroxide or a substance that inhibits oxidation. Substances that protect cells against the effects of free radicals (molecules produced when body breaks down food or are exposed to radiation) are antioxidants. Some of the more well-known antioxidants include ascorbic acid (Vitamin C), alpha-tocopherol (Vitamin E), beta-carotene, and enzymes such as catalase, superoxide dismutase and glutathione peroxidase.

Im|portant infectious diseases in farm animals, such as pneumonia and enteritis, are thought to be associated with oxidative stress (a chemical phenomenon involving an imbalance in the redox status of the individual animal). The pig erythrocytes exhibited the lowest resistance to oxidative stress in vitro.

Inflammation is a normal body response to attack of viruses, bacteria, fungi, etc. or body repairs itself. Reactive oxygen species (ROS) are produced during the process of inflammation. The body has a built-in ability to neutralize these reactive compounds once they have done their work. In presence of inflammation, the body's own natural antioxidants may become depleted, allowing reactive oxygen species to accumulate and damage normal healthy cells. Damage to DNA that results in the formation of cancer cells is a well-known and much feared consequence of ROS.

Oxidative stress is the imbalance of pro- and antioxidants leads to oxidative stress and is highly detrimental to meat animal production. The factors that affect the effectiveness of antioxidants are activation energy, rate constants, oxidation–reduction potential, ease with which the antioxidant is lost or destroyed (volatility and heat susceptibility), and antioxidant solubility.

Advantages

Chronic inflammation includes longstanding allergic dermatitis and chronic arthritis can be prevented by supplementing antioxidants.

Vitamin E, Vitamin C, carotenoids, Se and other trace minerals are antioxidant components of animal diets and they are important in animal health and immune function. Antioxidants are generally safe to use. Use of balanced supplements is better than individual vitamins and minerals to prevent toxicity.

The process of converting the starch in grain into ethanol for bio-fuel has increased the availability of feed-grade co-products, such as dried distillers' grains, and dried distillers grains have become a common ingredient in livestock diets. Dried distillers grains are rich in polyunsaturated fatty acids (PUFA), which are highly oxidative. Inclusion of various antioxidants into diets containing dried distillers grains alleviates the effects of oxidative stress.

Synthetic phenolic antioxidants (butylated hydroxyanisole [BHA], butylated hydroxytoluene [BHT], and propyl gallate) can effectively inhibit oxidation to maintain the quality of ready to eat food products.

The addition of both Vitamin E and a commercial antioxidant blend improved growth and liver function in pigs fed a diet high in oxidants, which is something the vitamin E alone did not do. Some of the scientists could relate beneficial effects of antioxidant vitamins in coronary artery disease. It has been proven that

antioxidant supplements like selenium have ant-carcinogenic effects.

The addition of the antioxidant blend proved to be helpful in improving the growth performance of pigs fed a high-oxidant diet. Studies show that, dietary addition of antioxidant blend or antioxidant blend and Vitaimin E was effective in improving growth as well as liver function and plasma markers of oxidative stress. Plant polyphenols (reducing agents occurring in grapes, berries and nuts) have antioxidant properties and are able to sequester free radicals. By uptake in the intestinal cells polyphenols are well suited to counter oxidative stress locally in the intestines, thereby strengthen the gut barrier function. This protection reduces the number of infections and result in healthy, growing piglets.

Weaning is the most challenging stage that has significant bearings on pig welfare and growth performance in swine industry. Phytochemicals (plant chemicals/metabolites) are one of the substitutes for in-feed antibiotics because of its wide spectrum antibacterial activities and some are potential anti-viral agents too. Further it is found that phytochemicals could act as antioxidants to remove free radicals from the body and protect animals from oxidative damage.

The intestinal dysfunction occurring after weaning leads to an inhibition of the antioxidant system and this can be prevented by the antioxidant blend which has the potential to prevent free radical-induced damage and suppress oxidative stress. Hydroperoxides and oxidative stress index are good indicators of health disorders around weaning and plasma concentration of vitamin E before weaning is associated to growth after weaning.

The shelf life of raw pork under commercial conditions is enhanced by dietary antioxidant supplementation in pigs which improved in vivo antioxidant status and exerted antioxidant and antimicrobial effects.

It is an established fact that an optimal level of antioxidants is required to maintain ocular tissues safe. Boars with higher seminal plasma total antioxidant (SP-TAC) capacity have better fertility rate, suggesting that SP-TAC can be considered as a potential fertility biomarker for boars.

Disadvantages

Supplementing surplus oxidants damage animal cells and tissues and may ultimately impair animal health and growth. Meat flavor, texture, color and nutritive value will be adversely affected by diets that are high in oxidants. Recently it is found that excess removal of ROS can result in upset cell signalling pathways and actually increase the risk of chronic disease as ROS exert essential metabolic functions. An excessive consumption can lead to diseases such as formation of bladder stones by eating high concentrations of vitamin C.

Supplementation of antioxidants may prevent body from making its own antioxidants which are produced naturally. Further consumption of antioxidants won't prevent or cure any diseases. Another deleterious effect is they may act as pro-oxidants when taken at high concentrations. Long term supplementation can be toxic and harm the body.

Conclusion

It can be concluded that antioxidants can be taken from a variety of natural foods rather than completely depending on supplementation. The following are some of the sources:

a. Vitamin A from carrot, beetroot, sweet potato, spinach.

b. Vitamin C from citrus fruits, berries, raw cabbage and broccoli.

c. Vitamin E from whole grains, nuts, fish oil, and green leafy veggies.

d. Selenium and manganese minerals from seafood, nuts, and whole grains.

e. Flavonoids from tea, coffee, and berries.

f. Resveratrol from dark grapes.

g. Phytoestrogens from peanuts and soybeans.

ISSN : 2279-0454
October - December, 2019

11

WETLAND AS CARBON SINK

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Wetland is an "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres". Wetlands are amongst the most productive ecosystems on the Earth and provide many important services to human society. However, they are also ecologically sensitive and adaptive systems. It exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry, dominant species, and soil and sediment characteristics. Globally, the area extent of wetland ecosystems ranges from 917 million hectares to more than 1275 m ha with an estimated economic value of about US$15 trillion a year. They provide a potential sink for atmospheric carbon but if not managed properly, they become a source of green house gases. However, only limited studies have been conducted to assess the roles and potentials of wetlands in carbon sequestration. They are often termed as "Nature's Kidneys" of landscape because of their ability to store, assimilation and transform contamination lost from the land before they reach waterways.

Wetlands are also referred to as "Biological Supermarkets" because they have extensive food webs that attract animals species, they possess unique habit and they are also rich in biodiversity. Wetland soils contain a disproportionate share of the earth's total carbon. Although they occupy only between 5% and 8% of the earth's total land surface, their soils hold 35% or more of the estimated 1,500 gigatons (Gt, or billion metric tonnes) of organic carbon that is stored in soils. Despite their importance, wetlands have been historically under appreciated, and an estimated 87% of global wetland area has been lost since 1700. They are threatened by pollution, transformation, water extraction, and modification. Such disturbance can undermine a wetland's ability to capture carbon, but critically, damage to wetlands can also release significant amounts of carbon that have already been stored.

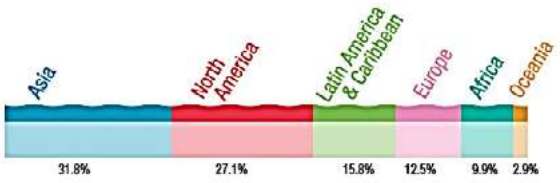

Fig. 1 Regional distribution (%) of wetland area

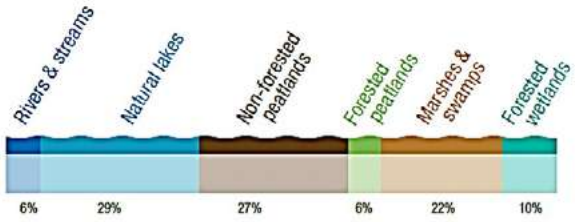

Fig. 2 Relative areas (%) of natural inland wetland classes

Carbon Sinks

Carbon sinks absorb more carbon then they release acting like sponges that can soak up carbon compounds such as carbon dioxide. They are either a natural or artificial (man-made) reservoir that can store carbon for an indefinite period. The process through which carbon sinks can remove carbon dioxide from the atmosphere is called "carbon sequestration". Natural carbon sinks are plants, soil, and oceans. Drainage and degradation of wetlands can release significant amount of this stored carbon back into the atmosphere in the form of methane and reduce the ability of wetlands to sequester additional carbon. Better management practices can help protect these stored of carbon and the ability of wetlands to sequester it. Plants grab carbon dioxide

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October - December, 2019

from the atmosphere to use in photosynthesis; some of this carbon is transferred to soil as plants die and decompose. Combined the Earth's land and ocean sinks absorb about half of all carbon dioxide emission from human activities.

Why are carbon sink important

Climate change is an immense challenge. The earth's climate is changing at an unprecedented rate. The effects of a changing climate are many and vary by location, with intensifying storm activity, rising sea levels and more frequent floods and droughts predicted. Internationally renowned experts have highlighted that to avoid the most serious impacts of climate change we need to limit global warming to 2 degree Celsius between now and 2100. This is no easy task; it means that global greenhouse gas (GHG) emissions need to be reduced by 40 to 70 percent by 2050 and that carbon neutrality (i.e Zero emissions) needs to be reached by the end of the century at the latest. Ways to mitigate climate change is very important and Carbon sinks could play a very important role. Globally wetlands represent just three percent of total land area, but sequester 30 percent of all soil carbon. It has been estimated that different kinds of wetlands contain 350-535Gt C, corresponding to 20-25% of world's organic soil carbon.

Mechanism of Carbon Storage in Wetland

Wetland ecosystems have unique characteristics as they are the sources of cultural, economic and biological diversity. These unique characteristics affect carbon dynamics and there are few mechanisms that aid in carbon storage in wetland ecosystem. Plants absorb carbon dioxide from the air *via* pores in their leaves, called stomata, and perform photosynthesis to convert this gas into carbon, stored in their bodily tissues like roots, stems and leaves. Animals which consume plants called herbivores, transfer the stored carbon into the soil *via* their excreta. Plants and animals, on dying, are decomposed by soil microbes, which also release carbon. Soil carbon is stored in the form of decomposing plant and animal fragments, microbes such as nematodes, and fungi, and in the form of a mineral-carbon composite called humus. Most of the carbon dioxide is sequestered in the oceans by plankton and aquatic plants which absorbed it via photosynthesis. When these die, they sink to the bottom and decompose, releasing carbon deposits.

Factors Influencing Carbon Deposition and Long Term Storage in Wetlands

The balance between carbon input (organic matter production) and output (decomposition, methanogenisis, etc.) and the resulting storage of carbon in wetlands depend on several factors such as

- the topography and the geological position of wetland
- the hydrological regime
- the type of plant present
- the temperature and moisture of the soil
- pH and the morphology

Carbon sequestration in various types of wetlands at a global scale

Wetlands are critical to mitigating climate change through capture and storage of carbon. They have an important and underestimated role in both carbon storage and the regulation of greenhouse gas emissions. The Expert Meeting on Water, Wetlands, Biodiversity and Climate Change, involving the Ramsar Secretariat, the Ramsar Scientific and Technical Review Panel (STRP) and the Secretariat of the Convention on Biological Diversity (CBD), concluded that it is time for the international community to recognise that wetlands are more important as carbon stores than many other biomes and that efforts to protect them should be expanded. There are still uncertainties about the overall carbon balance in wetland systems, and even about the global area of wetlands and their existing carbon stocks. The Ramsar STRP calculated in 2007 that there were 1,280 million hectares of wetlands (9 per cent of the planet's land surface), but this may be an underestimate. It is estimated that they contain about 35% of the global terrestrial carbon.

Coastal and estuarine wetlands have one of the highest primary productivities on earth but are small in their total global area.

Fig. 3 Coastal & estuarine wetlands

Seagrass meadows cover anywhere less than 0.2% of ocean floor, but store about 10% of the carbon buried in the ocean each year. Seagrasses are being lost at the rate of 1.5% per year and have lost approximately 30% of historical global coverage.

Fig. 4 Seagrass meadows

Mangroves cover about 14-15 million hactares around the world but are steadily disappearing.

Fig. 5 Mangroves

ISSN : 2279-0454
October - December, 2019

These coastal forests trap an estimated 31 to 34 billion kilograms of carbon every year, making them carbon storage powerhouses.

Fig. 6 Peat

Peat covers about 3 per cent of the global land surface (4 million km2) but is believed to contain the planet's largest store of carbon. Peatlands store about 30% of terrestrial carbon (400-700 Giga tons)

Floodplain areas are often the most productive in the landscape, and consequently the capacity for carbon storage is high. However, watering of floodplains may lead to anaerobic conditions and emissions of methane into the atmosphere.

Fig. 6 Peat

Global potential and actual carbon storage and estimated impact of human on the carbon storage capacity of vegetation

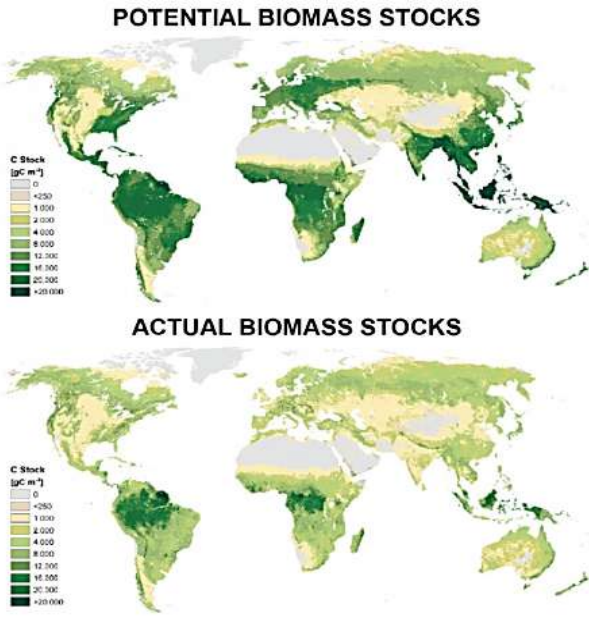

Fig. 8 Map showing potential and actual carbon storage in global vegetation (in grams per square metre)

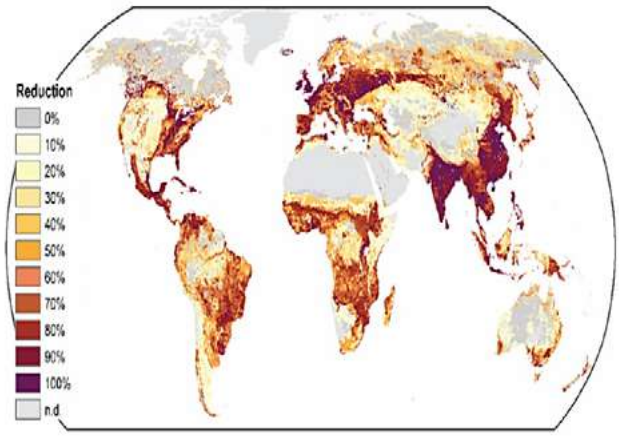

Fig. 9 Map showing the estimated impact of humans on the carbon storage capacity of vegetation

Conclusion

Wetlands play an important role in landscape function, including cycling of carbon, water and nutrients, food and fibre production, water purification, regulation of flows, provision of habitats, support for animal migrations, and tourism and recreation services. Wetlands are centres of high productivity in the landscape and therefore have a high capacity to sequester and store carbon. Because wetlands currently store significant amounts of carbon, drainage and degradation of wetlands results in large emissions of atmospheric carbon. There are synergies between programs to conserve wetlands for biodiversity conservation and climate change adaptation/mitigation. Further information and research is required on wetlands, including inventories of wetland area and type, baseline carbon storage, sequestration and emission rates, and measurement/modelling of carbon flows in different types of wetlands.

ISSN : 2279-0454
October - December, 2019

12

PROMISING EXOTIC VEGETABLES FOR NORTH EAST REGION OF INDIA

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Exotic vegetables are plants or plant parts that are originating from another country (foreign) and introduced in our country, and which are not common in domestic crop production or in the traditional Indian cuisine. They have a strange or bizarre allure, beauty, colourful, quality, more nutritious, aesthetic value, medicinal value, etc. Globalization has brought many opportunities and changes in developing country like India, therefore, exotic vegetables are now occupying a space of pride in mall and super market shelves of the metropolitan cities. These vegetables are used in preparation of exotic dishes in big hotel, fast food restaurant, home, etc. Leafy exotic vegetables like celery, lettuce, parsley, Florence fennel, etc. are used as salad whereas others such as broccoli, kale, collard, edible podded pea, etc. are cooked, boiled, blanched, soup and preserved. Due to urbanization and people have more concern on health, more awareness on nutritious vegetables, curiosity in growing colourful vegetable for nutrition as well as for aesthetic value so started growing of exotic vegetables for consumption as well as for selling. They are grown and sold at higher price than our Indian vegetables. Nowadays there is higher profit in growing of exotic vegetables than cultivation of other vegetables.

North east region peoples are fond of leafy vegetables along with non-vegetarian items. Cultivation of such exotic vegetables will enhance their livelihood in terms of health, wealth and happiness. Thus, growing of exotic vegetables has a great scope in the region.

Potentials of high value exotic vegetables in the country

- Demand of these vegetables in fast food restaurant, five star hotels in large metropolitan cities.
- Popularity of exotic cuisine increases with its passing day with the influx of foreign tourist.
- Exotic vegetables are adding colour and quality in food plate to attract the people.
- The diverse agro-climatic conditions offer ample opportunities to the farmers to grow such vegetables for profitability with less area require.
- As per day by day demand of exotic vegetables, market is increasing at the rate of 15 to 20% per annum.
- There is a scope for contract farming in future specially for export purpose.
- India is importing more than 85% exotic vegetables.
- Exotic vegetable has major two niche market hotel industry and export.
- Growing of exotic vegetable is more profitable business than cultivation of traditional Indian vegetables.
- Due to urbanisation, the lifestyles of people are changing day by day, so demand is increasing in domestic market to get nutritive and delicious taste.

Promising important exotic vegetables for north east region

Exotic vegetables can be grown to meet the demand of local market as well as metro cities and export market. Some of the promising important exotic vegetables which can be grown in the region are given below:

Common name	Scientific name	Family	Plant part used
Cherry tomato	*Solanum lycopersicum* var. *cerasiforme*	Solanaceae	Fruit
Capsicum	*Capsicum annuum*	Solanaceae	Fruit
Lettuce	*Lactuca sativa*	Asteraceae	head & Leave

ISSN : 2279-0454
October - December, 2019

Celery	*Apium graveolens* var. *dulce*	Apiaceae	Long fleshy petiole & leave
Broccoli	*Brassica oleracea* var. *italica*)	Brassicaceae	Flower bud
Red cabbage	*Brassica oleracea* var. *rubra*	Brassicaceae	Head
Brussels sprout	*Brassica oleracea* var. *gemmifera*	Brassicaceae	Head
Kale & Collard	*Brassica oleracea* var. acephala *Brassica oleracea* var. viridis	Brassicaceae	Leave
Chinese cabbage	*Brassica rapa* var. *pekinensis & chinensis*	Brassicaceae	Head & Leave
Asparagus	*Asparagus officinalis*	Liliaceae	Tender Shoot
Parsley	*Petroselinum crispum*	Apiaceae	Leave
Florence fennel	*Foeniculum vulgare* var. *dulce*		Swollen part of petiole
Leek	*Allium ampelopra-sum* L *var. porrum*	Alliaceae	Stem & leave
Snow pea/ Chinese pea	*Pisum sativum* var. *saccharatum*	Leguminosae	Tender pod
Snap pea/ Sugar snap pea	*Pisum sativum* var. *macrocarpon*	Leguminosae	Tender pod
Baby corn	*Zea mays*	Gramineae	Tender cob
Blue corn	*Zea mays* sub sp. *mays*	Gramineae	Tender cob

Problems with exotic vegetables

- The method of farming and selling exotic vegetables differs from the typical farming.
- Skilled labour is required for cultivation of these vegetables.
- For growing exotic vegetables the specific climatic as well as soil conditions require.
- Production and productivity of most of the exotic vegetables are low.
- Problem of biotic and abiotic factors
- Most of the exotic vegetables need to cultivate under protected condition.
- Lack of proper market or market fluctuations.
- Lack of improved production technologies.
- Lack of improved varieties.
- High cost of seed
- Lack of proper research on exotic vegetables in the country

Suggestion for overcoming problems

- Establishing post-harvest units
- Awareness and training for the growers
- Development of cost effective production technology
- Establishment of proper market.
- Quality seed production
- Developing improve varieties with desirable traits

Cultivation of exotic vegetables

Climatic and soil requirement of most of the exotic vegetables prefer cool climate and requires well drained fertile soil. Some of these crops required to grow under protected condition e.g. Capsicum (coloured), Cherry tomato, etc. while others are cultivated in open condition.

Brief cultivation practices and their uses are given below:

Broccoli (*Brassica oleracea* var. *italica*)

- Uses: Salad, cooked, Anti-carcinogenic and antioxidant
- Seed rate: 400-500 g ha^{-1}. Sowing: August-September
- Spacing: 45-60 x 30-50 cm
- Nutrition: FYM 20 t ha^{-1} + 326 kg Urea+500 kg SSP+100 kg MOP + 500 g Molybdenum + 10-15 kg borax
- Harvesting: Before flower buds open and loosen of head
- Yield: 15-20 t ha^{-1}

Fig. 1 Broccoli

Kale (*Brassica oleracea* var. *acephala*) **Collard** (*Brassica oleracea* var. *viridis*)

- Anti-carcinogenic
- Seed rate: 400-500 g ha^{-1}
- Spacing: 60-90 x 45-60 cm

Fig. 2 Kale

Fig. 3 Collard

ISSN : 2279-0454
October - December, 2019

- Sowing: Oct-Nov (Plain), Aug-Sept. (Hill)
- Harvesting:
  * Kale- cut entire plant at 40 DAT or pick lower leave periodically
  * Collard - all green parts, any time after attaining 25-30 cm height
- Yield: 150-200 q ha^{-1}

Lettuce (*Lactucasativa*)


Fig. 4 Lettuce

- Uses: Salad, soups, sandwiches and wraps or grilled, low calories, effective for diet food
- Medicinal properties: Cardio protective, anti-allergy, Vit. C
- Seed rate: 2.5 kg ha^{-1}
- Sowing: Feb.-Jun (Hill), Sept.-Oct. (Plain)
- Spacing: 45 x 30-45 cm or can grow in pot
- Harvesting: when leaves and heads well formed. Leaf becomes bitter as the temperature rises.
- Yield: 10-15 t ha^{-1}

Parsley (*Petroselinum crispum*)


Fig. 5 Parsley

- Uses: Salad, rich in Fe, K,Vit. E, C, B, anti-carcinogenic
- Seed rate: 7-12 kg ha^{-1}
- Sowing: Sept.-Nov. (Plain), Mar-May (Hill)
- Spacing: 30-60 x 10-15 cm or can grow in pot
- Harvesting: Pick the outer and larger leaves periodically, make into small bunches for market and finally harvest the entire plant.
- Yield: 150-200 q ha^{-1} (fresh herb) and 20-30 q ha^{-1} (dried herb)

Florence Fennel (*Foeniculum vulgare* var. *dulce*)


Fig. 6 Florence fennel

- Most decorative among the exotic vegetables, swollen part of petiole as well as leaves are used raw and cooked, sweet and pleasant smell.
- Seed rate: 10-12 kg ha^{-1}
- Sowing: Mid-September to mid-October
- Spacing: 30-45 x 25-30 cm
- Once the stem start to swell, earthing up half way with soil to make swollen stem whiter and sweeter. Ready to harvest at 70-80 days

Cherry Tomato (*Solanum lycopersicum* var. *cerasiforme*)


Fig. 7 Cherry Tomato

- Higher flavonoids content than normal tomato, good for heart, blood pressure, bones
- Popular in continental hotel for dressing dishes
- Suitable under polyhouse
- Spacing: 50x50cm
- Nursery: Raise in protrays, seedling age: 5-6 true leaves stage
- Staking & Pruning: Staking with bamboo stick & twine with thread. Keeping 2 stem $plant^{-1}$
- Harvest when fully ripen along with calyx to look attractive

Chinese Cabbage (*Brassica rapavar. pekinensis* & *chinensis*)

- Uses:Kimchi, cooked, salad, rich in Ca, Vit. A and C
- Seed rate: 400-500 g ha^{-1}
- Sowing: October-November


Fig. 8 Pe- tsai


Fig. 9 Pakchoi

- Spacing: 45 x 30 cm, 25 x 25 cm Harvesting: Cut whole heads when they are compact and firm
- Yield: 25-50 t ha^{-1}

Asparagus (*Asparagus officinalis*)


Fig. 10 Asparagus

- An important perennial vegetable crop and can yield up to 10 years.
- Mostly grown in backyard garden
- Cool season crop, well grown in fertile and well drained loam soil
- 1st harvesting of spear- 2 years after planting
- Seed rate: by suckers or 2-3 kg seed ha^{-1}

ISSN : 2279-0454
October - December, 2019

- Planting time: Mar-Apr. in hills; July-Nov. in plain. (germinate after 3-4 weeks)
- Practice blanching for white spear
- Harvest after 6 months of planting
- Yield: 12-30 t ha^{-1}

Snap Pea (*Pisumsativum* var. *macrocarpon*)

- Edible podded pea – whole pod consume, rich in protein, sweet and crispy
- Off-season cash crop - can grow in hill during summer
- Grown during winter in plain (Oct-Nov) and summer in hill (Mar-Apr)

Fig. 11 Snap pea

- Seed rate: 80-90 kg ha^{-1}
- Spacing: 30-50 x 10 cm
- Harvest tender pods even if matured the whole pods can be consumed
- Yield: 120-150 q ha^{-1}

Capsicum (*Capsicum annuum*) (coloured capsicum)

- Uses: cooked or raw, baking, stuffing, sliced in salads and pizzas
- Sowing: Nov. (Polyhouse), August for autumn-winter and November for spring- summer

Fig. 12 Capsicum

- Seed rate: 1.25 kg ha^{-1}
- Spacing: 45-60 x 30-45 cm
- Harvest fresh fruits of firm, crispy and marketable size
- Yield: 125-150 q ha^{-1} (fresh) of OP variety and 250-300 q ha^{-1} (hybrid)

Case Study/Success story

Shri Ramesh Verma, a farmer at Kasimpur Biruha, Lucknow is a very innovative and enthusiastic farmer having marginal land holding (0.506 ha). He has successfully introduced the cultivation of exotic vegetables in Lucknow district. Earlier, he was farming with his father and cultivated only rice and wheat with some vegetables like, cabbage, cauliflower, tomato, potato and banana. This farming practice provided good returns only to meet out the family expenses. He visited KVK, ICAR-IISR, Lucknow and received broccoli seeds from the KVK and started cultivating it. He continued to grow broccoli till 2009-10 since he was getting excellent returns from its cultivation.

Fig. 13 Exotic Vegetable cultivation

After he attended training programme at the KVK, ICAR-IISR, Lucknow, started growing these exotic vegetables in his entire land (0.506 ha) during 2011-12. He not only became the famous farmer in the area but also an expert in exotic vegetables cultivation. Scientists of KVK, ICAR-IISR guided him on the availability of market for sale of these exotic vegetables. Accordingly, he sold these vegetables to various multinational retailers and hotels.

Economic of exotic vegetables cultivation revealed that cost of cultivation of these vegetables grown in an area of 0.506 ha with Rs. 26,400 which gave gross and net returns of Rs. 336,500 and Rs. 310,100 respectively for the year 2011-12. The benefit: cost ratio worked out on the basis of net returns and cost of cultivation was 1:11.75, which is a remarkable achievement by a marginal land holding farmer, Shri Ramesh Verma.

He is an inspiration for the farmers of the area. Approximately 300 farmers from distant places, 250 trainees of Union Bank of India, government as well as private agencies have visited his field. The QRT of ICAR-IISR, Lucknow has also visited his field and highly appreciated the practices of growing exotic vegetables in such a remote village. (Source: Higher Profit from Exotic Vegetables Cultivation, Krishi Vigyan Kendra, ICAR-IISR, Lucknow)

Conclusion

Growing of exotic vegetables which are suitable with climatic condition and consumer preference of the region are in need of the hour. There is a great scope and opportunity for these crops in the region due to increase in population, urbanization, change in life style, food habit, increase in fast food restaurant, health conscious, awareness of higher nutritive value of these crops and higher profit. Improve cultivation technology should be adopted for higher production of exotic vegetables to meet the demand of consumers.

ISSN : 2279-0454
October - December, 2019

13

STATUS OF LIVESTOCK WITH SPECIAL REFERENCE TO MITHUN HUSBANDRY UNDER AGRO-CLIMATIC CONDITIONS OF NAGALAND

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Livestock is an integral part of the regional economy. A variety of livestock are available in the entire region. The land-man-livestock ratio in the region is higher than the same in the national level. However, most livestock are of non-descript type and the yield rate is low. Thus not only the milk and milk products but also the meat and meat products are in short supply in the region. Livestock is considered as subsidiary income for the rural households. In Nagaland along with agriculture, backyard pig and poultry rearing is integral to the livelihoods of farmers. Mithun is a massive semi-domesticated rare ruminant species mainly reared for meat. This strongly built hill animal of Southeast Asia plays an important role in the socio-economic and cultural life of the local population. Mithun is reared at an altitude of 1000 to 3000 meters above mean sea level under free grazing condition in its natural habitat. Due to gradual denudation of forests (natural habitat of Mithun) and tremendous socio-economic and cultural importance of Mithun in the life of the local tribal population, initiatives are being taken to popularize economic Mithun farming under semi-intensive condition with controlled breeding.

The Northeastern India is a chicken-necked region, connected to the mainland with a narrow corridor and surrounded by international boundaries of Bangladesh and Bhutan. This unique characteristic adversely affects the economy and other regional factors, such as a sense of isolation, remoteness etc. Northeastern India consists of Assam, Arunachal Pradesh, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim covering 255.08 million ha, which is about 8% of country's land mass. More than 64% of the total geographical area is covered by thick and deciduous forest (164.101 million ha under forest). Except a small valley plain of about 30%, the rest 70% is hilly and mountainous track of very steep to moderate slope. Thirty per cent of valley plain consists of upland, lowland, deep water and very deep water ecological situation. The region is highly diverse in terms of agro-eco-system, socio-cultural mixture of the people, a blend of multiplicity of ethnicity and geo-topographical variability.

Nagaland is located between $25^0$10'N and $27^0$4'N Latitude and $93^0$15'E and $95^0$20'E Longitude with a total geographical area of 16,579 km in the northern extension of the Arakan Yoma ranges. The state shares a long international border with Myanmar in the East and is bounded by state of Assam in the west and north, Arunachal Pradesh the North and Manipur in the south. Currently Nagaland has 12 districts, namely, Kohima, Dimapur, Kiphire, Longleng, Mokokchung, Mon, Peren, Phek, Tuensang, Wokha, Zunheboto and Noklak, 114 sub-districts, 26 towns (19 statutory and 7 census towns) and 1428 villages. Physiographically, the state has vast undulating terrain and mountainous landscapes that include high hill slopes, hilly dissected terrains, denudational hill slopes, undulating upland, and narrow valleys with presence of perennial streams and moisture supporting rich biodiversity.

Land Use

The forest area in Nagaland is 0.86 million ha and it constitutes 52.04% of the total area reported for different land utilization in the state. Total cropped area has grown from 0.4 million to 0.52 million ha from 2008-09 to 2016-17 and is around 31.5% of the total land utilization reported. Total fallow including current fallow is 14% and it has grown from 89.4 thousand ha to 153.0 thousand ha from 2008-09 to 2016-17. The total cultivable waste land has reduced to 66 thousand ha. Area under trees and groves constituted 7% of the land reported under different utilization. (Source: Statistical Hand Book, Nagaland 2016-17)

ISSN : 2279-0454
October - December, 2019

Climate

Nagaland has a typical monsoon climate with variations ranging from tropical to temperate conditions. Monsoon is the longest lasting for five months from May to September with May, June and July being the wettest months. Owing to varied topography and relief annual rainfall varies from 1000 mm to over 3000 mm at different places with an average of 2000 mm. Atmospheric temperature varies from 15^{0}C to 30^{0}C in summers and from less than 5 to 25^{0}C in winters. Altitude variation in Nagaland is among the prime factors affecting climate and weather conditions. Relief features such as high mountains act as barriers for the movement of the Monsoon winds. Low temperature, high rainfall on windward slopes, comparatively dry on the leeward side and heavy precipitation in the form of snow at the mountain tops are the main features of the climate.

Agro-climatic Zones

The state is classified in to four agro climatic zones, namely High Hills, Low Hills, Foot Hills and Plane areas. These zones have distinct characteristics with regard to soils, crops, rainfall and biodiversity. Rice is the main crop grown in all zones and it is mostly single crop but sometimes other crops like maize, millets and vegetables are taken along with rice. The cropping pattern across different agro climatic zones is presented is presented in **Table 1 and 2**.

Table 1 Dominant paddy based cropping system under different Agro-climatic conditions of Nagaland

Agro-climatic zones	Cropping syatems
High Hills	Rice-Potato/vegetables Rice/Maize-Mustard, Rice
Low Hills	Rice-Wheat+Mustard Rice-Potato
Foot Hills	Rice-Potato Rice-Vegetables
Plain Areas	Rice-groundnut, rice-rice-cowpea, Rice-wheat-rice, Rice-pulses, rice-linseed.

(Source: http://cgwb.gov.in/gw_profiles/st_nagaland.html)

Table 2 Agro climatic zones and cropping pattern of horticulture crops

Crop zones	Elevation range	Important horticulture crops grown
Foothills & Lower Hills **Sub Temperate**	<800 m Temperature: (8-38^o C)	**Fruits:** Pineapple, Mango Papaya, Guava, Citrus, Banana, Litchi, Jack fruit, coconut, cashew nut **Flowers:** Anjuriuim, gerbera, orchid **Vegetables:** Cabbage, cauliflower, pea, bean, brinjal, tomato, potato, root crops, cucumber etc **Spices:** Naga Mircha, turmeric, black pepper, ginger
Mid & High Hills **Sub Temperate**	800, >1500 m Temperature: (3-24^{o}C)	Plum, Pear, Peach, Kiwi, Mango, Banana, Passion fruit, Apple, Cherry, Walnut, Chestnut, Pear, Plum, Kiwi, Peach Flowers: Rose, lilium, alstroaemeris, dry flowers, carnicium Vegetables: Broccoli, chowchow and Cabbage, cauliflower, pea, bean, brinjal, tomato, potato, root crops, cucumber Spices: Large cardamom, ginger, naga chili, naga mircha, naga garlic

Source: Department of Horticulture, GON, 2011

Livestock Scenario in Nagaland

Livestock is an integral part of the regional economy. A variety of livestock are available in the entire region. The land-man-livestock ratio in the region is higher than the same in the national level. However, most livestock are of non-descript type and the yield rate is low. Thus not only the milk and milk products, but also the meat and meat products are in short supply in the region. Livestock is considered as subsidiary income for the rural households. In Nagaland along with agriculture, backyard pig and poultry rearing is integral to the livelihoods of farmers. Dairying is not generally practiced by farmers except in some small pockets of Dimapur district as Nagas are not milk consuming people. In Nagaland the trend shows that the stocking rate of all species is declining mainly because of increased management costs, lack of feed resources, increased risks due to disease and lack of market stimulus. Pig keeping in Nagaland is traditional and very common, they are maintained because pig rearing is socio-religious obligation and provides additional income to households. Also pig keeping helps rural

ISSN : 2279-0454
October - December, 2019

households to diversify their risks. The stocking rate of pigs in Nagaland ranges between one to three per household but some households from Dimapur district keep up to 15 pigs. ILRI (2008) reported that Dimapur had the highest density of pigs per 1000 people (471) and Mon the lowest (143). Pig rearing is not complex since they are fed on by-products of paddy, maize, taro, vegetables and gathered forages. Among all meat animals pig keeping is still considered as an excellent source of subsidiary income for poor because the pork consumption in Nagaland is highest among all NER. During the period 1996-2005 the production of livestock products has increased in the state. However, milk productivity of crossbreds has declined whereas in non-descript animals it has increased. Similarly productivity of meat produced from small ruminants, pigs and beef is marginally increasing along with eggs.

Mithun Husbandry

Mithun is a massive semi-domesticated rare ruminant species mainly reared for meat. This strongly built hill animal of Southeast Asia plays an important role in the socio-economic and cultural life of the local population (Simoons, 1984; Mondal *et al.,* 2010). In India, Mithun meat is considered to be more tender and superior over the meat of any other species. At present, Mithun farmers rear this animal at an altitude of 1000 to 3000 meters above mean sea level under free grazing condition in its natural habitat. Due to gradual denudation of forests (natural habitat of Mithun) and tremendous socio-economic and cultural importance of Mithun in the life of the local tribal population, initiatives are being taken to popularize economic Mithun farming under semi-intensive condition with controlled breeding. While wild Indian Gaur, the ancestor of Mithun, is in a vulnerable position (Baillie and Groombridge, 1996). The present free ranging Mithun rearing system permits grazing of limited number of these animals in a particular hill pocket without any migration to other locations and vice versa that results in considerable inbreeding in this species.

Mithun is believed to have originated more than 8000 years ago and considered to be descendent from wild Indian gaur (Simoons, 1984). Mithuns are found over a large area of Southeast Asia. Their natural habitat is the forests of highlands. Mithun, a unique bovine species has a limited geographical distribution. It is mainly found in the tropical rain forests of North Eastern hilly states of Arunachal Pradesh, Nagaland, Manipur and Mizoram of India. The total Mithun population in the country has registered a growth rate 30% in 2019 as compared 2012 census. Total mithun population in Arunachal Pradesh, Nagaland, Manipur and Mizoram is 350154, 23123, 9059 and 3957 respectively. Total mithun population in India as per 20th Livestock census is 386293. Percentage share of mithun population is Arunachal Pradesh, Nagaland, Manipur and Mizoram is 90.64, 5.98, 2.34 and 1.02 percent respectively (20th Livestock Census, 2019).

Scientific rearing system

Currently farmers rear Mithun under free-grazing condition in the forest area without any additional housing or feeding facilities. Occasionally, farmers bring back the female mithun just before parturition and send it back to the forest following parturition. However, it is suggested that even under a free-range system, a temporary housing structure using locally available materials can be constructed in some strategic locations in the mithun rearing area. Mithun can also be trained to come to the shed at a particular time every day by providing little bit of concentrate and salt. This will be helpful for farmers to supervise, provide additional feeding and medication to their animals. Besides, farmers will also get an opportunity to look after the individual animal regularly for any kind of discrepancy or disorder. If farmers opt for semi-intensive system of rearing they should go for housing structures with feeding and watering provisions and they can also tie the animals at night once they come back from the forest after grazing. The supervision of individual

ISSN : 2279-0454
October - December, 2019

animals, additional feeding, watering and medication can be done there in late evening or early morning.

Feeding

Mithun thrives on the jungle forages, tree fodders, shrubs, herbs and other natural vegetations (Das *et al.,* 2010). Farmers do not provide any additional feeding. Though the animals are owned by the farmers, they are kept under natural forest in a semi-wild condition. However, farmers occasionally provide common salt, especially at the time of restraining for some purposes. Each individual owner can identify his Mithuns even though they do not bear any identification marks and similarly each Mithun knows his owner which is reflected in the fact that the Mithun approaches the owner periodically for salt. In other words, the owner does not have to invest anything in his Mithun as they are simply let loose in the forest which constitutes around 50% of total land area of the region. Owners generally keep Mithuns in community herd in fenced hilly jungle area and village councils assign Mithun grazers to take care of their animals.

As Mithun entirely depends on the locally available jungle fodders, special care should be taken in terms of mineral supplementation for better performances (Das *et al.,* 2010). In steep hilly slope, the leaching of mineral elements is a common phenomenon especially during rainy season. Therefore, in a particular hilly grazing gradient the soil will be deficient in some important mineral elements. In that case the vegetation of that particular area will also be deficient in some of the mineral elements, which may induce mineral deficiency. The only option to correct this situation is mineral supplementation. However, the salt licking behavior as well as drinking of mineral water sources in the hills is the natural way to meet the requirement of minerals in these animals (Prakash *et al*., 2013). During the lean season, when availability of jungle fodders goes down, additional concentrate supplementation may be required. It is advisable that during the flush season when abundant fodders are available in the jungle, the salt and mineral mixture together may be fed additionally to the animals to avoid mineral deficiency. Whereas, during lean season additional concentrate feed (15% CP and 70% TDN) fortified with salt and mineral mixture (1 to 2 kg per animal daily up to 2 years and 2 to 4 kg per animal daily above 2 years) may be offered to maintain optimum performances (Das *et al.,* 2010). For lactating Mithun, as it produces less quantity of milk, no additional feeding is required. In free-range Mithun, these feed supplements may be provided to the animals in the shed constructed in strategic location in the grazing area. Whereas, for animals under semi intensive system the feed supplements may be provided in the shed in late evening or early morning whenever the animals are tied. It has been found that the drinking water requirement for Mithun is approximately 9% and 12% of body weight, during winter and summer respectively. Therefore, the provision of adequate drinking water according to this specification is highly essential.

Breeding Management

Like cattle, Mithun is a poly-estrus animal. The healthy adult female mithun show repeated estrus cycles at an interval of 19 to 24 days unless it is pregnant. The Mithun breeds throughout the year and no definite breeding season is observed in this species. The length of gestation period, service period and calving interval in Mithun varies from 270 to 290 days, 50 to 100 days and 350 to 400 days, respectively. The age at puberty and age at first calving varies from 27 to 36 months and 40 to 48 months, respectively. The mithun bulls become mature to breed at 3 to 4 years of age. Under free-range system, a practical approach for selective breeding in Mithun is the introduction of superior and tested bulls (1 bull for 10 breedable females) in the herd and simultaneous culling of the unwanted bulls from the herd. Efforts should be made to replace breeding bulls preferably once in five years to avoid inbreeding depression. Under semi intensive system, the female can be detected in heat to be bred with superior bulls either through natural service or artificial insemination.

The expression of estrus behaviour is silent in mithun. Unlike cattle, it is difficult to detect heat in mithun through visual observations. Among all the behavioral signs of estrus, the mounting of mithun bull over estrus cow is the best indicator of estrus followed by standing of estrus cow to be mounted by mithun bull. Congestion of vulval mucous membrane and swelling of vulva are also important signs of estrus in mithun cows. In contrast, other signs like mucous discharge, restlessness and alertness, tail raising, frequent urination and loss of appetite were found to be less prominent estrus signs in mithun cows. Bellowing is not generally observed in mithuns during estrus. The genital organ of mithun cows during estrus reveals relaxed and open os externa of cervix, turgid uterus and ovaries having palpable follicles. However, it is suggested to use healthy mithun bulls to detect heat. In mithun, ovulation occurs between 20 to 31 hour after the onset of estrus (Mondal *et al.,* 2006).

Common Diseases in Mithun

Like other bovines species mithun reared in semi-intensive system suffers from various infectious diseases like Tuberculosis, Para-tuberculosis, Brucellosis, Foot and Mouth disease (FMD),

Infectious Bovine Rhinotracheitis (IBR), and Bovine Viral Diarrhea. (Rajkhowa *et al.,* 2003) which has tremendous detrimental effect on profitable mithun husbandry practices. Regular deworming, vaccination and treatment of ailing animal is required to be under taken to keep the animals healthy. Leech infestation is common in mithun, to undertake the treatment of it application of common salt solution in nasal cavity or ether inhalation or Ivermectin injection is suggested. Death may occur due to leech infestation in mithun, other non infectious diseases like tympany, debility, anemia, hypovitaminosis are very commonly observed and needs proper attention and supplementation to overcome these ailments. Mithun is endangered species and scientific rearing and research is required to be to under taken to increase socio-economic status of tribal people in hilly areas of Northeastern region by increasing the production potential and performance of the animals. Further more emphasis should be undertaken to start with semi-intensive type of housing system by adopting better Managemental practices in mithun rearing.

Climate projections for Nagaland in 2021-2050

Climate parameter	Districts	Projected Change in 2021-2050s with respect to base line (1961-1990)
Temperature	Kohima, Wokha, Phek, Zunheboto and Tuensang,	+ 1.7 -1.8°C
	Mon, Longleng and Mokokchung	+1.6°C-1.7°C
Precipitation	Kohima, Zunheboto, and Phek	+20%
	Wokha and Tuensang	+15-20%
	Mon, Longleng and Mokokchung	+10 -20%
Extreme rainfall (>100 mm/ day)	Phek, Tuensang, Kohima	>2 or more days
	Zunheboto, Wokha	1.0 – 2.0 days
	Mon, Mokokchung	0– 1.0 days

(Source: Ravindranath et al., 2011)

Impacts of climate change on Livestock and livestock products

In livestock, global warming and climate change are likely to impact negatively on production and health. Increase in physiological reactions at high temperatures will elevate heat loads of animals resulting into a decline in productivity of meat, wool, milk and draught power (Upadhyay *et al.,* 2008). Higher temperatures and changing rainfall patterns can enhance the spread of existing vector borne diseases (Bhattacharya *et al.,* 2006) and macro parasites, accompanied by the emergence and circulation of new livestock diseases. Climate change will modify the dispersal, reproduction, maturation and survival rate of vector species and consequently alter viral and bacterial disease transmission. In some areas, climate change is likely to generate new transmission models. Temperature and humidity variations could also have a significant increase in helminth infections, protozoan diseases such as Trypanosomiasis and Babesiasis. Increase in temperature favours bacteria to grow fast in the milk and spoil the milk quickly causing economic loss to farming community. Rising temperatures will have an additional impact on the digestibility of plant matter. Raised temperatures increase the lignifications of plant tissues and thus reduce the digestibility and the rates of degradation of plant species. This not only affects the health of an animal but also results in the reduction in livestock production which in turn has an effect on food security and incomes of small livestock keepers. Infertility cases are likely to increase in cattle mainly due to mineral deficiency possibly due to high soil erosion causing trace minerals leaching out.

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October - December, 2019

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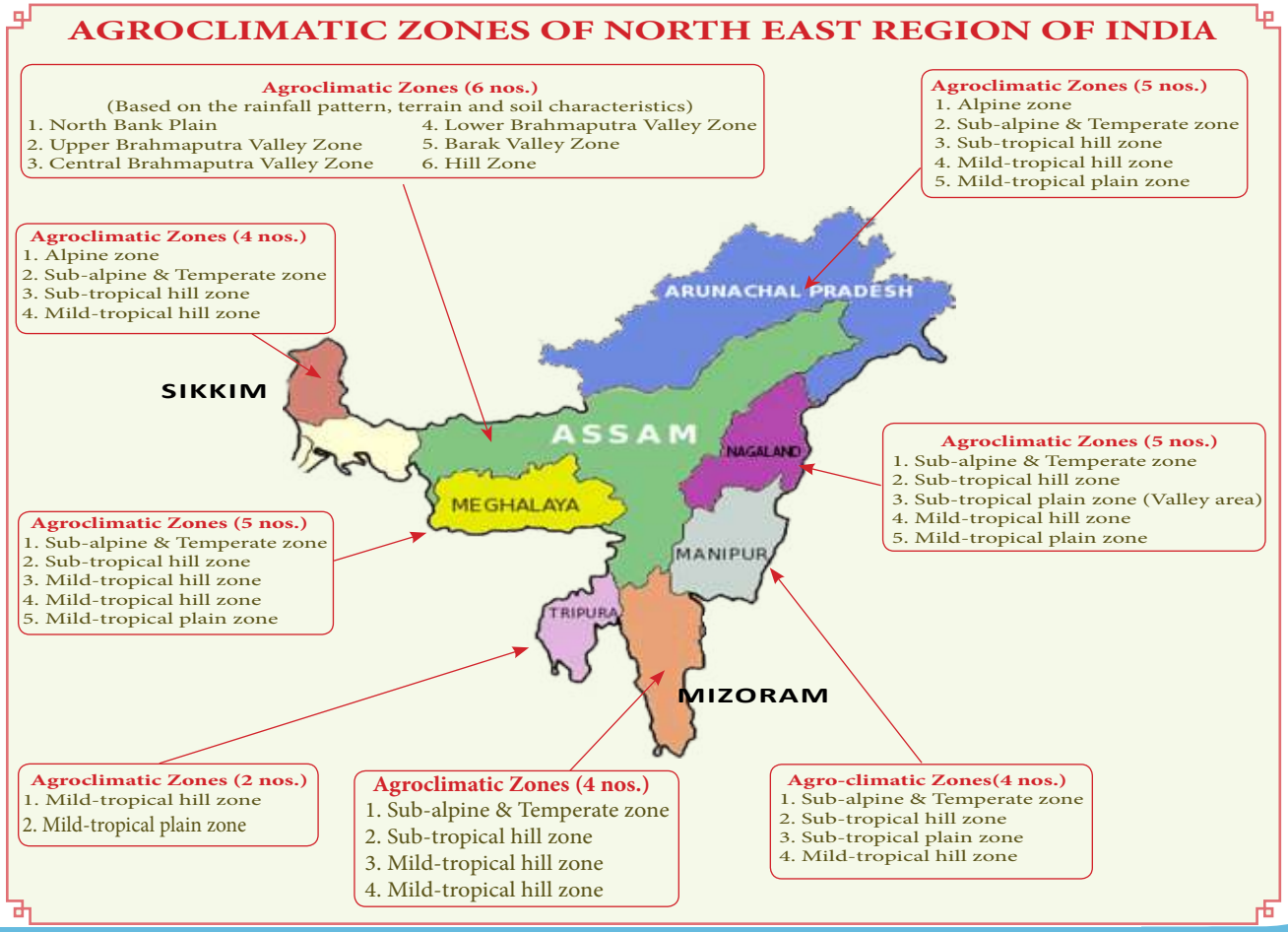

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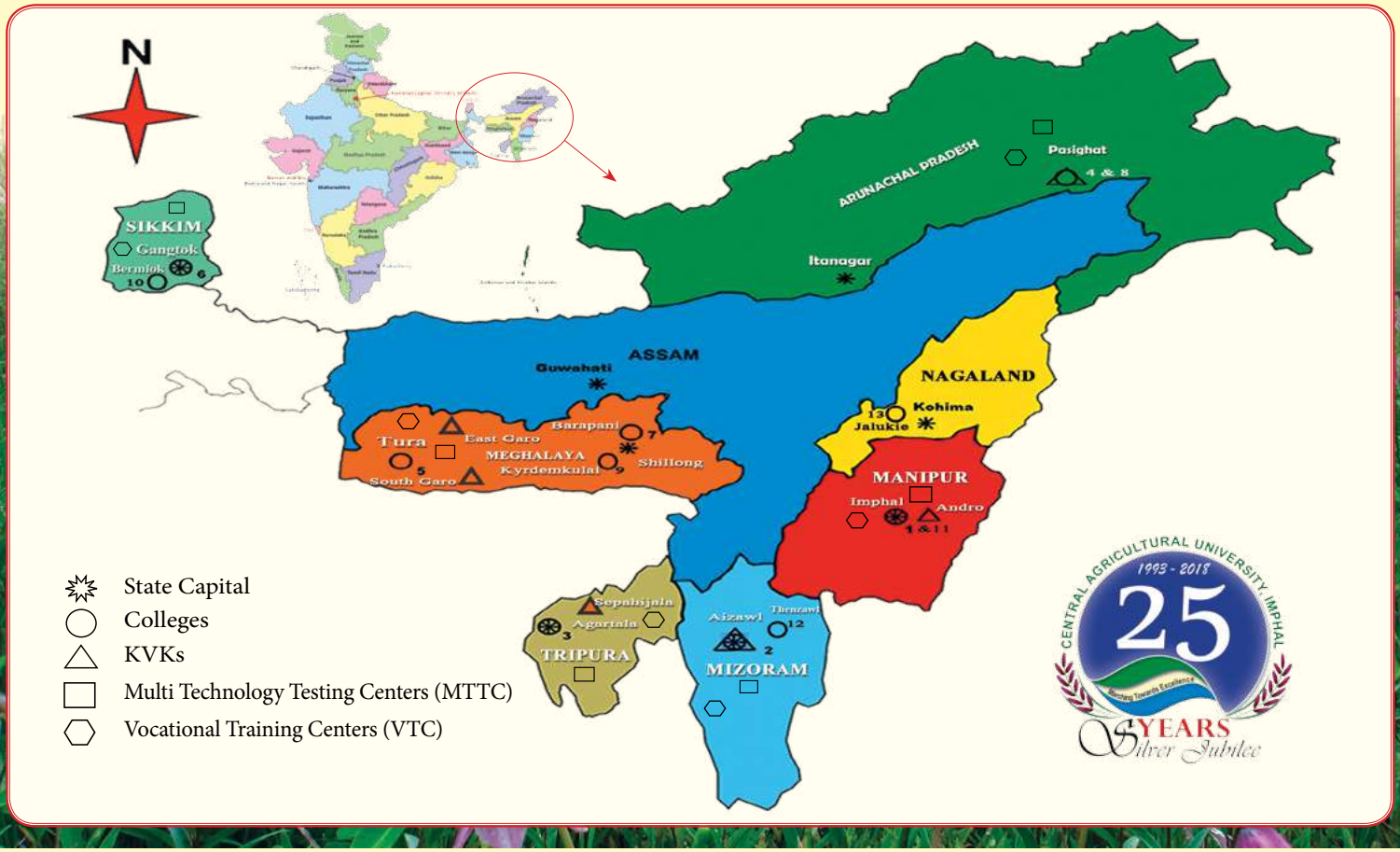

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