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Poultry Coccidiosis: a continuous economic threat to poultry Industry

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ABSTRACT

Poultry industry is a leading profitable sector in livestock farming in India with high growth rate and huge potential in future to feed the ever increasing population. Coccidiosis is an important disease of poultry which badly compromises the production and affects the poultry producer's income. It is an apicomplexan protozoan parasitic disease, widely prevalent in our country as well as throughout the world and the poultry farmers are well exposed to it because of its frequent occurrence. The broiler chicks are more prone to the disease in comparison to layers or breeders mainly because of the rearing system adopted. Chemoprophylaxis is widely practiced throughout the country by including anticoccidial feed additives in chick ration. Still, complete inhibition of its occurrence cannot be materialized because of the high biotic potential, sturdy infective stages, short prepatent period and ease of the parasite's survival and transmission. Here, sound management and hygienic practices complimented with farmer's awareness can play a pivotal role in early parasite detection, reduced transmission, lesser mortality and ultimately decreased potential economic losses to be caused by the disease.

Keywords: Poultry, Coccidiosis, *Eimeria*, parasitic disease, economic losses

INTRODUCTION

The poultry sector in India has been transformed over decades from unorganized backyard activity into organized commercial activity where commercial sector shares about 80% of the poultry market. It is one of the fastest growing subsectors of animal husbandry with present growth rate of around 6-7% for layer and 8-10% for broiler industry (Vision 2050, ICAR-DPR). Globally, India is ranked 3rd in egg and 5th in meat production with per capita availability of 54 poultry eggs and 2.36 kilograms per annum poultry meat which is much lower than ICMR's recommended requirement of 180 eggs and 10.8 kg meat per annum (Vision 2050, ICAR-DPR). However, poultry products have a potential to meet the increasing demand of low cost, safe and healthy animal food/ protein for the growing population, there are many serious threats on its sustainability.

Among all the health threats, coccidiosis is economically one of the most significant disease of poultry industry worldwide. It is an old yet well recognized protozoan parasitic disease in its clinical form but remained under-estimated and under-recognized in its sub-clinical form. The clinical coccidiosis is recognized by prominent signs of mortality, morbidity, diarrhoea or bloody faeces but the sub-clinical form is manifested mainly by poor weight gain and reduced efficiency of feed conversion and is economically more detrimental. Although the disease is self limiting and is largely controlled by good management and hygienic practices, still the increasing drug resistance in the coccidian parasite, the increasing consumer's preference for animal/bird products raised under no-antibiotic-ever (NAE) system and the ability of coccidiosis-causing parasites to survive the environmental challenges has insisted the poultry producers to revise their coccidiosis control programmes time and again. This article is an attempt to provide all the essential information about poultry coccidiosis and to highlight the disease related concerns which threaten the secure production of poultry-derived food products. Although, the word poultry includes a wide range of domesticated birds including chicken, turkey, geese, ducks etc., but in this article, as coccidian species are host specific and those affecting chicken are most detrimental and also the chicken contributes more than 85% of the poultry industry products, so the word "poultry coccidiosis" here focuses mainly on the disease in chicken.

Economic impact of poultry coccidiosis

Coccidiosis in chicken is an economically noticeable disease with the global annual losses of about 3 million US dollars to the chicken producers (Suvethika *et al.,* 2018). The losses are in terms of mortality loss, production losses resulting from decreased egg production and reduced body weight gain, increased feed conversion ratio and expenses on chemotherapy as well as chemoprophylaxis and vaccination cost. In India, deep litter system of broiler chicken rearing makes them more affected with coccidiosis. The study estimating the economic losses due to coccidiosis revealed that commercial broiler industry is major sufferer sharing 95.61 % of the total losses due to the disease, mainly due to reduced body weight gain followed by increased feed conversion ratio while commercial layer industry shares only 3.53 % economic losses mainly due to the cost of chemoprophylaxis and reduced egg production (Bera *et al.,* 2010). The economic losses of Rs. 1.14 billion are estimated to Indian poultry market by coccidiosis for the year 2003-04 (Bera *et al.,* 2010).

Cause of poultry coccidiosis

Chicken coccidiosis is caused by prozoan parasites of phylum Apicomplexa and seven species from the genus *Eimeria*: *E. acervulina, E. brunetti, E, maxima, E. mitis, E. necatrix, E. praecox and/or E. tenella.* The age group of chicken mostly affected by these species, their location in intestine and severity of their pathogenicity are tabulated in Table 1. The previously recognized two more species, namely *E. mivati* and *E. hagani* are not considered as valid species now. Apart from this, two more coccidial species, *Cryptosporidium tyzzeri* and *Wenyonella gallinae* are also present in chicken but are non

pathogenic. Generally mixed infections are present in outbreaks where a mixture of two or more *Eimeria* spp. is present in the infections.

General Life cycle of poultry coccidia:

There are two main phases in the life cycle of *Eimeria* spp. (Figure 1); one phase occurs outside the host (in environment) called sporogony involving the development of the infective stages (oocysts), and the major phase which occurs within the host and involves massive asexual multiplication (schizogony) and sexual reproduction (gametogony and syngamy).

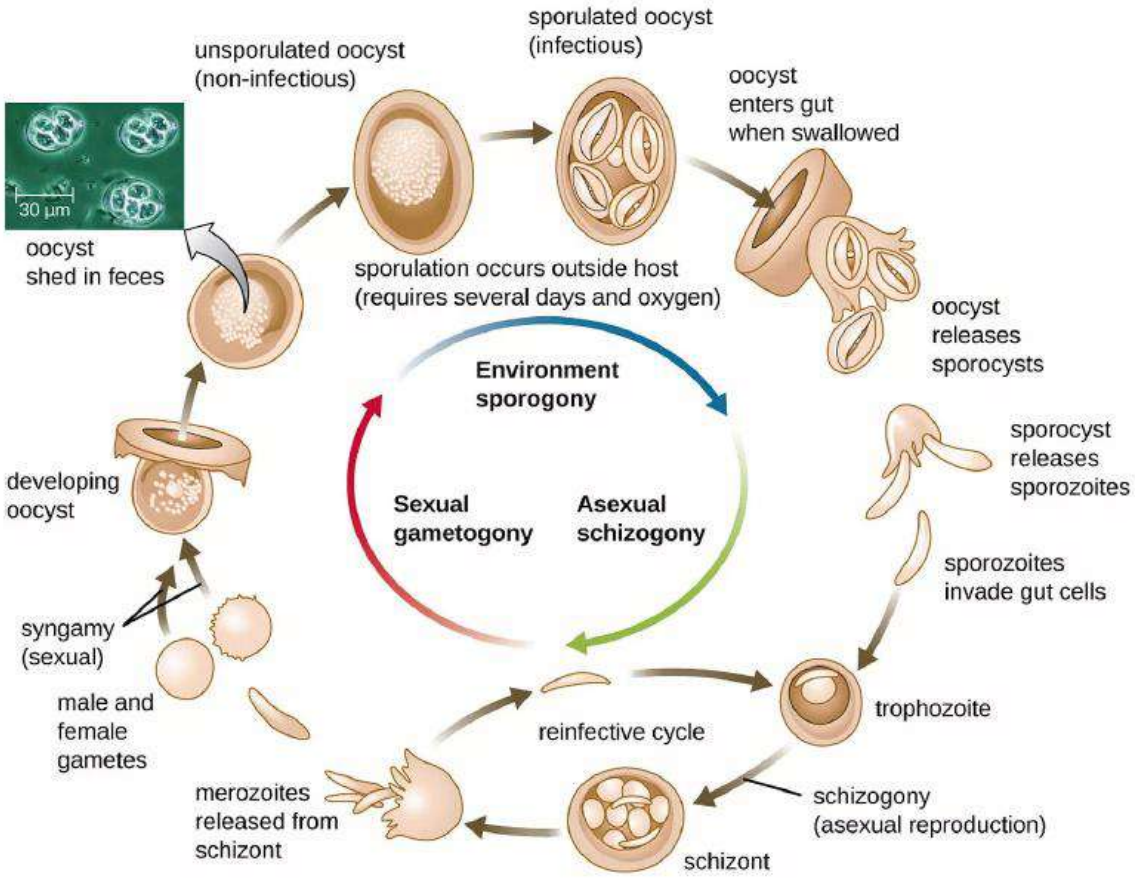

Figure 1: General life cycle of *Eimeria* spp. in chicken (source: CNX OpenStax http://cnx.org/contents/5CvTdmJL@4.4)

The life cycle starts as the oocyst, or microscopic egg, is passed through the infected chicken's droppings. The oocyst develops to become infective (sporulate) in wet, humid conditions, easily provided around feeders and waterers, especially if these areas are not cleaned and maintained properly. If proper hygienic practices are not followed then these infective oocysts can also be spread from infected farm to uninfected farms unknowingly by clothings, shoes etc. of farm workers/visitors or equipments, such as shovels or pails etc. Birds become infected by ingesting oocysts either through feed/ water or scratching the ground. The number of oocysts ingested and the immune status of the host bird decides the severity of clinical signs. Young chickens (under six months of age) are most susceptible to the disease due to the lack of development of natural immunity. The oocyst then hatches inside chicken and invades the cell lining of the

chicken's small intestine. It multiplies in different parts of intestine depending upon the species infecting the bird (Figure 2). Here it multiplies rapidly through a number of cycles, rupturs the bowel cells and ultimately release large number of oocysts in the droppings. These oocysts after sporulation again are capable of infecting other birds in the surroundings. The prepatent period of disease is 4-8 days depending upon the *Eimeria* spp.

Factors affecting the disease epidemiology:

There are many factors which facilitate the disease transmission, predispose the birds to coccidiosis or affect the severity of disease pathology. These factors ultimately affect the disease epidemiology and should be taken into account by poultry producers in order to face least losses due to the disease. These are:

1. **Parasite related factors:** The severity of the disease depends on both the species of *Eimeria* and the size of the infecting dose of oocysts. High biotic potential and short prepatent period of parasite rapidly increase the infecting oocysts and thus helps the disease to spread like a wild fire.
2. **Host related factors:** The disease occurrence is affected by age of the bird, flock density, whether the birds are getting infection for the first time, number of passages or ability of the bird to develop proper specific immune response. Coccidiosis generally affects young birds between 3 to 18 weeks of age, but may occurs at any age. If the infecting dose is small then usually birds acquire immunity without the occurrence of clinical disease, followed by reduced oocyst shedding. Thus, adult birds are usually carriers of oocysts which can severely infect the susceptible young birds.
3. **Management related factors:** Wet litter, contaminated drinkers and feeders, bad ventilation, high stocking density, same laborer for all the pens or any stress causing factor (transport, debeaking etc.) will predispose the birds to coccidiosis or will increase the severity of clinical signs. Proper management practices play a pivotal role in disease epidemiology as it is almost impossible to raise coccidia-free poultry, but we can prevent its spread by maintaining proper hygiene.

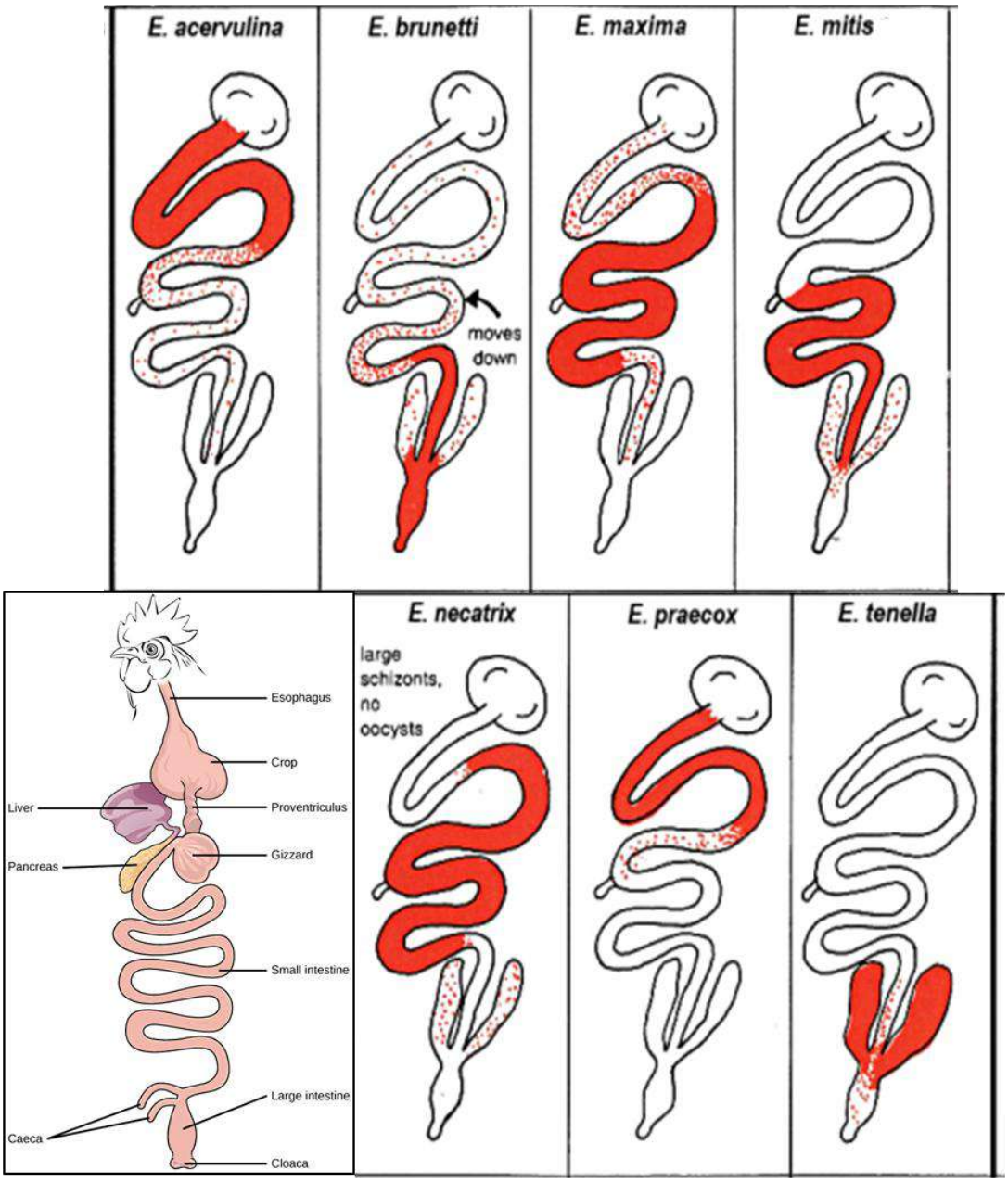

Figure 2: Diagramatic representation of the location (coloured as red area) of various species of *Eimeria* in the intestinal tract of poultry. (Source: Peek H., 2010 and Figure 34 01 06.jpg - Wikimedia commons)

4. **Nutritional factors:** Chicken usually fed on wheat based diets are more adversely affected than those fed on maize based diet, as higher amount of soluble non-starch polysaccharides in wheat increases the digesta viscosity. Diets higher in crude proteins may also increase the coccidial pathogenicity due to increased tryptic activity which leads to more efficient oocyst excystation.
5. **Others:** Immunosupressive diseases such as viral diseases of poultry (MD, IBD) or stressful conditions also make them more susceptible to coccidiosis. Presence of mycotoxins in poultry feed, even at permitted levels, may also aggravate the incidence and severity of coccidiosis by facilitating parasite colonization in the gut. Coarse feed particles, mycotoxins etc. may disrupt the intestinal cells which

further can be used as a growth substrate for pathogens such as *Eimeria, Clostridium* and *Escherischia coli*.

Clinical signs

Clinical signs of coccidiosis depend upon the *Eimeria* species affecting the bird, number of oocysts ingested at a time, age and immune status of bird and management sytem. If large numbers of oocyst of more pathogenic species are ingested by young birds which are reared in intensive system and deep litter system then the clinical signs will be most prominent leading to clinical form of disease. Otherwise, subclinical forms persist which may go unnoticed by poultry producers. In clinical forms, often yellow diarrhoea is the first and foremost symptom and affected birds display a characteristic posture as they hunch up, fluff up and can drop their wings. They may have diarrhea having soft mucoid faeces or bloody droppings, pink intestinal tissue in droppings, depression, weakness and listlessness, loss of appetite or even interest in water, pale comb or skin, weight loss (in older chickens), decreased growth rate (in young chickens), failure to lay eggs or laying eggs inconsistently and high rate of mortality may be seen in severe cases. Not all chickens will display the same symptoms and all of these symptoms might not be present in all the affected chickens.

Diagnosis of coccidiosis

The best way to diagnose coccidiosis is post mortem examination of affected birds as soon as possible. The location of parasitic lesions in intestinal tract and the type of lesions as given in Figure 2 and Table 1 and will be indicative of *Eimeria* spp. which will further be confirmed by oocyst finding in intestinal scrapings/ droppings and histopathology.

Table 1: Various species of Genus *Eimeria* with their location in intestinal tract, age group of birds mostly affected, their pathogenicity and main macroscopic lesions found during post mortem.

Sr no.	Species	Location in intestine	Age group affected	Pathogenecity	Main lesions on post mortem
1	*Eimeria tenella*	Caecum	4 weeks	Most pathogenic	Caecal core/ caecal plug, petechial haemorrhages, dilated caeca, thickened wall and scar after core detaches
2	*E. necatrix*	Schizogony in mid intestine, Gametogony in caecum	9-14 weeks	2nd most pathogenic	Marked ballooning in mid intestine, salt and pepper lesions including mild haemorrhagic spots and white opaque foci surrounded by zone of haemorrhages

3	*E. maxima*	Mid intestine	Young	Moderately pathogenic	Slimy orange or pink to yellowish mucoid exudates, impaired absorption of xanthophyl and carotenoid pigment
4	*E. brunetti*	Rectum, caeca proximity	4-9 weeks	Markedly pathogenic	Salmon coloured flecks, haemorrhagic streaks in mucosa, rice bran like mucosal contents due to blood stained eroded shreds
5	*E. acervulina*	Duodenum/ Anterior small intestine	Young	Moderate to severely pathogenic	Ladder like transverse bands on serosal and mucosal surface, watery whitish diarrhea, no haemorrhages
6	*E. mitis*	Ileum	Young	Less pathogenic	Limited enteritis causing fluid loss. Malabsorption of nutrients
7	*E. praecox*	Anterior small intestine	Young	Least pathogenic	Watery intestinal contents, Mucus and mucoid casts

Breifly, oocysts with lesions in the caeca are *E. tenella,* in duodenum are *E. acervulina* or *E. praecox*, in mid intestine are *E. necatrix* or *E. maxima* and oocysts with lesions in the lower gut are *E. mitis* or *E. brunetti.* Many times the gross lesions are pathognomonic for species, like caecal plug/caecal core for *E. tenella*, salt and pepper like lesion with ballooning of mid intestine for *E. necatrix*, salmon coloured flecks or rice bran like mucosal contents in *E. brunetti* and ladder like transverse bands on serosal and mucosal surface in *E. acervulina*. Apart from this histopathology of intestinal tissue gives clear cut picture. Microscopic identification of oocysts after sporulation can also be helpful which require technical expertise. For this, computational analysis of microscopic images of oocysts is also possible now by a software called COCCIMORPH and molecular techniques like PCR involving ITS-1 and ITS-2 gene sequence are also used. Examination of feacal sample for oocysts may give false interpretation of disease pathogenicity, as existence of large number of oocysts may not necessarily indicate a severe pathogenic condition. Among various coccidian oocysts, species identification can be possible only after sporulation and that again is not easy.

Treatment

Early treatment is very important because coccidia must be killed within the bird before irreparable damage is done to the intestines and birds may die within a couple of days in severe cases. Anticoccidial drugs are of two types– coccidiostats and coccidiocides. Coccidicidal (cidal) medications kill the parasite but coccidiostatic (static) do not kill the parasites, but arrest their development irreversibly. Coccidiostats are given in the feed mostly to prevent the disease. For therapeutic purpose, coccidiocides likes sulphaquin® (Sulphaquinoxaline), Coccivet® (Amprolium, Ethopabate) and Baycox® (Toltrazuril)

are given usually in drinking water to kill the parasite. A combination of amprolium and sulphaquinoxaline @ 1g/L of drinking water for 2 days, then 2 days gap and repeat of same drug @ 0.5 g/L for next 2 days is also considered as standard chemotherapy (Bera *et al.,* 2010). Generally, coccidiocides dose rates are carefully balanced to kill enough of the coccidia to save the bird, yet still enable immunity to develop. In treating for coccidiosis more is not better as overdosing can be toxic to birds. Supplementary vitamin treatment (especially A and K) is also helpful.

PREVENTION AND CONTROL

a) **Chemoprophylaxis:** Prophylaxis of coccidiosis is more helpful than treatment as the parasite causes maximum damage before the clinical signs become apparent and severely affected birds remain unproductive even after successful treatment. Disease prevention can be done by means of chemoprophylaxis, immunization by vaccination, sound hygienic and management practices etc. In India, commercial broilers are mostly raised in deep litter system and critically require the prophylaxis while commercial layer, broiler and layer breeders are maintained mainly in the cage system for which prophylaxis is barely required. Chemoprophylaxis by using coccidiostatic drugs like maduramycin, diclazuril, salinomycin are in generally practiced by mixing in feed from day old to 16 weeks of age of birds. An effective coccidiostat will always inhibit the schizogonic stage and in turn develops immunity. But continuous use of these anticoccidials has lead to a further problem of drug resistance and drug residues in consumable meat and eggs. To combat drug resistance, shuttle and rotation systems of drugs are employed but still they can minimize resistance development, not fully prevent it. The different drugs are used during a period of juvenile growth to market size growth in shuttle programme, whereas the type of drug used is switched after one or several grow-out periods or seasonally in rotation programme. Alternative control measures are as follows:

b) **Vaccination:** Immunization by vaccination utilizes the concept that, mostly birds acquire infection in the first few weeks of life which induces a species specific good immunity. Immunity is best engendered by repeated exposure to low numbers of oocysts, so-called 'trickle' infection, and this is what usually takes place naturally. Initially live unattenuated vaccines (Coccivac, Advent, Immucox, and Inovocox) were used, but now their use is limited due to the risk induced by the live parasites and also they were recommended to be used along with chemical treatments to control the inherent pathogenicity of the parasites. But now live attenuated vaccines (Livacox, Paracox and HatchPak CocciIII) are more popular as there is a lower risk of disease occurring because there is a reduction in the proliferation of the parasites and as a result less damage to the intestine of the bird. Today, attenuation of *Eimeria* species is mostly based on “precociousness” where attenuated virulence is achieved by repeated passaging and collection of first shed oocysts are used for next infection resulting into a population of parasites that complete their life cycle up to 30 h faster than

parasites from the same parent strain indicating a significant reduction in their reproductive capacity and thus pathogenicity. In India, mostly Livacox Q, a live attenuated vaccine containing mixture of most pathogenic species like *Eimeria tenella, E. acervulina, E. maxima* and *E. necatrix* species is used in some of the breeder farms where cost of each dose was calculated as Rs 4.00 by Bera *et al.* (2010) and may be slightly increased today. Coccidia vaccination is not practiced commonly for commercial layers. Recently, a subunit vaccine, **CoxAbic** is also formulated and is used in some countries.

c) Sound management for coccidiosis control: Apart from chemoprophylaxis and vaccination, several management and hygienic practices should be followed, this includes:

1. To raise chicks on clean dry litter and avoid crowded or damp conditions. Litter should always be kept dry and special care and attention should be given to litter in which the farms located near water bodies.
2. To make sure drinkers are not spilling water into the litter. If possible, provide poultry nipple waterers, rather than open watering areas.
3. To make sure water and feed is uncontaminated by droppings.
4. To use medicated chick starter or grower.
5. To ensure that chicks are warmly housed out of draughts.
6. New birds should be quarantined first, before introducing them into your flock as inspite of appearing healthy; they can be carriers of a number of deadly diseases including coccidiosis.
7. Raise chicks in isolation from mature or adult birds.
8. Do not allow wild birds or insects to come in contact with your birds.
9. Thoroughly clean and disinfect the brooder between broods. This includes any equipment the chicks will come in contact with. Once the premises are dry, place four to six inches of dry, fresh litter material (wood shavings or a commercial absorbent litter material) on the floor.
10. In severe cases, to raise chicks on a wire grill that can reduce ingestion of the oocysts and help recovery.
11. In severe cases, to reduce the protein level in the feed and to prefer maize based feed upon wheat based.
12. To monitor droppings during and after treatment. Often morning droppings can show blood, even if the day is normal. Putting newspaper under perches or on brooder floors can make the droppings easier to see.
13. Sunlight is a natural disinfectant. Incorporate as much natural sunlight into your brooder as possible.
14. Do not wear the same clothing or shoes, or use the same tools and equipment with your chickens that have been used for other activities or on a neighboring chicken farm.
15. In order to provide adequate space and ventilation, be sure each chicken has at least four square feet of space inside coops, 10 square feet in chicken runs and 6 square feet of flooring in brooders for week old chicks.

16. Adding probiotic supplements to your chicks' water can help create the conditions for competitive exclusion – a process where good bacteria compete for the resources of bad bacteria inside the gut. This can reduce the chances of infection with coccidiosis and improve immunity to other infections as well.

CONCLUSION

Poultry coccidiosis is a cosmopolitan parasitic disease with an enormous potential to have the detrimental effect on poultry production. It is considered almost impossible to raise the chicks in a coccidia-free environment. But the occurrence and severity of coccidiosis depend on many factors like the agent, host and management as well as environment related risk factors. Apart from this, early diagnosis made by aware farmers can save them from large economic losses. prevent the farmers Good hygienic measures and management practices are the best ways to prevent and control the disease.

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Forage crops holds potential for soil carbon sequestration: a measure for mitigating climate change

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Carbon present in the atmosphere mainly as carbon dioxide (CO_2). Negative changes in the climate are most significant process associated with an increased concentration of CO_2 in the atmosphere. This type of change is the biggest threat to agriculture in the years to come. CO_2 enters the atmosphere through burning of fossil fuels, solid waste, trees and other biological materials, and also as a result of certain chemical reactions. Atmospheric concentrations of CO_2 can be lowered either by reducing emissions or by taking CO_2 out of the atmosphere and storing it in different ecosystems. Soil carbon sequestration is the process by which atmospheric CO_2 is taken up by plants through photosynthesis and stored as carbon in biomass and soils. Sequestering carbon either into soil or into the vegetation is one of the effective means for mitigation of green house gas (GHG) emissions. In India, livestock production contributes 7% to the national GDP (Vision 2030, IGFRI) but productivity from the livestock sector is not satisfactory mainly due to improper nutrition. The country (India) faces a net deficit of 36% greens, 40% dry fodder and 57% concentrates (DADF, Annual Report, 2014-15, Govt. of India). So, there is a scope of diversify few portion land towards cultivation of forages. Contribution towards environmental sustainability depends upon the different methods focused in the storing of soil carbon in soil sinks. One of several management practices proposed to sequester atmospheric CO_2 as soil organic matter is to expand the area of crops such as forages that increase the annual crop residue carbon inputs to the soil.

Climate change

United Nations Framework Convention on Climate Change defines climate change as a change in climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. Different human activity

increases emission of gases like carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), popularly known as greenhouse gases (GHGs). Water vapor and chlorofluorocarbons (CFCs) are also contributing to the green house effect. Greenhouse gases in the atmosphere absorb heat radiation and increased in concentration of GHGs leading to more heat retention as well as increase in surface temperatures. Some of the indicators for climate change are higher temperature, changing of rainfall pattern, changing of snow patterns, more droughts, warmer oceans, rising sea level, melting glaciers etc.

Forage crops for soil carbon sequestration

Reducing agriculture's GHGs emissions and increasing carbon stock in the soil and biomass could reduce global GHG emissions. The capacity of agriculture lands to store or sequester carbon depends on several factors, including climate, soil type, type of crop or vegetation cover and different management practices. Results from several field experiments under various climatic conditions revealed that farming forage crops has a remarkable capacity to sequester carbon in soil. Bama and Babu (2019) conducted an experiment with three different forage crops and four different types of nutrient management. They found that after three years of experimentation Cumbu napier cultivated soil stored more carbon of 18.63 t/ha compared with fodder sorghum (17.62 t/ha) and lucerne (15.19 t/ha) cultivated soil. Kundu *et al*. (2019) reported that cultivation of perennial forages could store 50.16, 49.16 and 48.34 Mg/ha soil organic carbon after two years of study by setaria grass, signal grass and guinea grass as against initial value of 41.75, 41.28 and 40.27 Mg/ha, respectively. Nishanth *et al*. (2013) conducted an experiment during 2010-11 and reported that the total organic carbon present in the soil ranged from 0.65 to 0.89% before cultivation i.e. 57.67 t carbon/ha. After harvesting of crops, the calculated tonnes of carbon/hectare were 95.90 for hedge lucerne, 93.96 for hybrid napier, 86.83 for fodder maize and 85.54 for fodder cowpea. Sundaram *et al*. (2012) conducted an experiment to quantify the impact of changing soil organic carbon (SOC) storage with farming forage crops during 2010-11. They found that the amount of carbon sequestered in the soil varied from 1.09 % by fodder maize, 1.12 % by fodder cowpea, 1.33 % by hybrid napier and 1.31 % by hedge lucerne after harvesting was accomplished.

Role of soil carbon sequestration in climate change mitigation

Climate change mitigation can be defined as measures that reduce the amount of emissions or enhance the absorption capacity of greenhouse gases. India emitted 3,202 Million metric tons of carbon dioxide equivalents in 2014 which is 6.55% of world's total (USAID, 2018). There has been a drastic increase in the atmospheric concentration of CO_2 and other GHGs since the industrial revolution and the concentration of CO_2 in the atmosphere increased day by day. Among all GHGs, CO_2 has a significant impact on global warming partly because of its abundance in the atmosphere. Worldwide soil is one of the largest reservoirs, where carbon could be restored. The primary way by which carbon is stored in the soil is as soil organic matter (SOM). Carbon sequestration

reduces the enrichment of atmospheric CO_2, hence provided a great opportunity for reducing GHG emission and somehow mitigates the climate change.

Others importance of soil carbon sequestration in agriculture

- Carbon sequestration builds soil fertility and improves soil quality.
- Improves agronomic productivity.
- Protect soil from compaction and nurture soil biodiversity.
- Increased organic matter in soil, improves soil aggregation which in turn improves soil aeration, water holding capacity, reduces soil erosion and improves infiltration.
- Supply nutrient for growth of both plants and soil micro-organisms.

CONCLUSION

Unsystematic exploitation of nature by mankind to advantage its unending economic interests for luxury and comfort, made the natural resources in soil, water, air, livestock, crops and mother earth suffer beyond repair! But the forgiving mother poses mitigation options, these options contribute to the revival strategies to combat climate change, provided we take up the business seriously. Carbon sequestration is one of the biological mitigation options to slow down the climate change. Cultivation of forage crops has a potentiality to sequester carbon in soil and somehow mitigates the climate change.

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Underutilized fruits - potential for nutritional security and crop diversification

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Abstract

India possesses different agro-climatic zones varying from sub-tropical to temperate, wet temperate to dry arid zones with large variability in land topography. These ecological features led to the evolution of large plant biodiversity. A number of edible fruit plant species (Jamun, Pomegranate, Kainth, Lasora, Phalsa, Kaphal, Karonda, Bael, Fig, Ber, Galgal, Aonla, Jackfruit) viz. tropical, sub-tropical, arid and temperate types exist in wild forms in their natural habitats in the country, which are being used by the local inhabitants.In fact, these underutilized fruits are an important supplementary source of food for people living in remote rural areas or vicinity of forests. These fruits plants are nutritionally rich and can supplement the human diet with proteins, vitamins, phyto-chemicals, essential amino acids, micronutrients and antioxidants with different medicinal properties. Furthermore, these species thrive in their natural habitats and possess great resilience against the various biotic and abiotic stresses. Hence, keeping in view their usefulness, it becomes imperative to document these plant species and evaluate them for future use.

INTRODUCTION

Nature has provided us with different sources of life forms that have fulfilled the basic needs for our survival on this earth. Man collected these eatables in the wild forms before he learnt to cultivate them. Man identified those plants that were edible and acquired the knowledge for their propagation and domesticated some of them. While, a few crops (Mango, Banana, Grapes, Apple, Citrus, Guava, Litchi, Pineapple, Papaya etc.) with economic importance were identified and commercially exploited for establishment of orchards. A vast reservoir of edible fruit species remained relatively unknown and existed in wild form in their natural habitats. These wild fruits are underexploited and their economic importance has not been realised. Their ethno-botanical knowledge, nutritional values and medicinal uses are limited to those who live in the vicinity of such habitats. In human history, 40- 100,000 plant species have

been regularly used for food, fibers, shelter, industrial, cultural and medicinal purposes (Magbagbeola et al. 2010). However, only a small number of plants are widely used. The remaining plant diversity is underutilized (Jaenicke et al. 2006).

Underutilized fruit crops can bedefined as the crops which are less available, less utilized or rarely used or region specific (William and Haq, 2002). These underutilized species are nutritionally rich and adapted to low input agriculture (Dansi et al. (2012). With the increasing population and fast depletion of natural resources, it became necessary to explore the possibilities of using newer indigenous plant resources. Utilization and improvement of these species is constrained by lack of knowledge, inadequate understanding of taxonomy, biology and multiplication of these species. Most of the important underutilized fruits are Indigenous and easily available. Focusing attention on neglected and underutilized species is an effective way to help a diverse and healthy diet and to combat micronutrient and deficiencies, the so-called 'hidden hunger' and other dietary deficiency particularly among the rural poor and the more vulnerable social groups in developing countries (Simrandeep et al. 2018). So, this document is mainly emphasizing on the distribution, botany, habitat, cultural techniques, nutritional and medicinal values of different underutilized fruit crops.

1. Jamun(*Syzygiumcuminii*)

Jamunis an important indigenous evergreen tree of tropical and subtropical regions belonging to family Myrtaceae. The fruit is native to India or East Indies. In India it is generally grown from Indo- Gangetic plains in North to Tamil Nadu in South. The jamun tree is tall and handsome, evergreen, generally grown for shade, windbreak on roads and avenues. Jamun is commonly planted near Hindu temple because it is considered scared to Lord Krishna.

Synonyms : Jambul, jambolan, jamblang, Malabar plum, Java plum or black plum
Life form : Tree
Flowering : March – Mid-April
Fruiting : June – July
Propagation : Seed, Patch or T- budding in March.
Habitat: Jamun is successfully grown under tropical and sub-tropical climate. Jamun tree is somewhat susceptible to cold, drought and frost injury. It requires dry weather at the time of flowering and fruiting. Early rains are beneficial for better growth, development and ripening of fruits. The fruits show remarkable improvement in this respect after the very first shower of rains. Trees can be grown on a wide range of soil-calcareous, saline, sodic soil and marshy area. However, deep, well-drained soil are ideal. It does not like very heavy and light sandy soil.

Nutritional value: Seventy percent of jamun fruit is edible. Glucose and fructose are two major sugar found in the ripe fruit. The fruit is laden with a large number of minerals and provides fewer calories as compared to other fruits. The seed of fruit is also rich in protein, carbohydrates and traces of calcium have also been found. Nutritive value per 100 g of fruit is given below:

Protein	Energy	Ascorbic acid	Carbohydrates	Iron	Sodium	Carotene	Oxalic acid	Potassium
0.7 g	62 k cal	18 mg	14 g	1.6 mg	26.2 mg	48 mg	89 mg	55 mg

(Ghosh et al. 2016)

MEDICINAL IMPORTANCE AND ETHNOBOTANICAL USES:

- The fruit is an effective remedy against diabetes because of its effect on the pancreas. Seed contain glucose "Jamboline" which checks the pathological conversion of starch in to sugar in case of increased production of glucose. It is an effective food remedy for bleeding piles. Natural acids present stimulates the liver functioning by secretion of digestive enzymes.
- The decoction of bark skin or seed powder effectively control diarrhea and dysentery.
- An infusion of fresh tender leaves with honey is effective remedy for sterility and miscarriage.
- Bark is used to treat indigestion, sore throats, asthma, appetite loss, ulcer and dysentery.
- Jamun is processed to form a distinct flavor of jellies, jam, preservers and squash while, ripe fruits are fermented for fabrication of excellent quality wine.

2. Kainth (*Pyruspashia*)

Kainth is a small or moderate sized deciduous tree of Rosaceae family. Plant is native to Southern Asia and occurs in sub-tropical to temperate areas of the Himachal Pradesh. This species is distributed in China, Bhutan, Laos, Myanmar, Nepal Pakistan, Thailand, Vietnam and Afghanistan. Tree is thorny, open headed and medium in size. Plant bear fruits on spurs. Fruits are globose, small, five celled pome, edible, 2- 4 cm in diameter, dark yellow- brown, turning black on ripening and are covered with raised white or grey spots.Seeds are brownish black and shiny.

Synonyms : Jamtorts, Shegul, Mol, Mehal, Wild Himalyan pear
Life form : Small tree
Flowering : February – March
Fruiting : July – September
Propagation : Cuttings
Habitat: Plant prefers a good well drained loam soil and can also be grown in heavy clayey soil. Plant tolerates light shades but does not fruit so well in such a position. It tolerates atmospheric pollution, excessive moisture and a range of soil types if they are moderately fertile. Established plants are drought tolerant. Plants are very hardy and can tolerate minimum temperature up to -15 ^{0}C. The plant is very hardy and is not frost tender. It flowers in the month of April. The flowers are hermaphrodite (have both male and female organs in same flower) and are pollinated by insects. The plant tends to produce many dense upward branches.
Nutrition value: The size of fruit is up to 2.5 cm in diameter. The fruit is usually blatted, but even then it is not sweet. It is tasty when fully ripe, even when dried. The fully ripe fruit has a reasonable flavor and when blatted, is sweet and very pleasant. Nutritive value per 100 g of fruit is given below:

Sugars	Proteins	Ash	Pectin	Vitamin C	Phosphorus	Potassium	Calcium	Iron
6.80 g	3.70 g	1.00 g	0.40 g	1.20 mg	0.03 mg	0.48 mg	0.06 mg	0.01 mg

(Rymbai et al. 2019**)**

MEDICINAL IMPORTANCE AND ETHNOBOTANICAL USES:

- Fruits possess different antioxidant, antimicrobial, hypoglycemic, stomachic properties and are used to treat leishmaniosis, dysentery, eye problems, sore throat, digestive disorder, abdominal pain, irritability, anemia.

- The bark possess laxative, astringent, febrifuge and anthelmintic properties and is used traditionally for the treating peptic ulcer, fever, digestive disorders, typhoid fever and gastric ulcers.
- This plant can be used as a root- stock for the cultivated pear.
- The fruit is added to cattle feed to enhance milk production

3. **Lasora (*Cordia myxa*roxb)**

Lasora is a minor fruit that grows throughout India in arid and semi-arid regions. Lasora is native to India and grows in the sub-Himalayan tract and its outer ranges. Lasora is a fairly fast growing species belonging to family Boraginaceae. Trees can be identified from a distance by observing the prominent fissures on bark of the main bole of a tree approaching maturity. The inflorescence is cyme bearing bunch of light yellow colored hermaphrodite fragrant flowers axillary on current season's growth. Flowers are pedicillate, perfect, actimorphic, hypogymous and pentamerous. Fruit is drupe, 2 – 3 cm long green while unripe and yellowish brown at maturity.

Synonyms : Lehsuda, Gonda, Indian cherry, Salora, Large sebesten, Gandhapushpa
Life form : Small tree
Flowering : March - May
Fruiting : July – September
Propagation : Seed, Patch budding and cleft grafting (July – September)
Habitat: It thrives well under tropics as well as sub-tropics upto an elevation of 5,000 feet. Plants are resistant to drought but sensitive to frost. It can tolerate temperature as low as 1^0C and high as 49^0C and grows well in the areas having rainfall from 250 to 3000 m. Plants have great capacity to grow in stress due to water or salinity. However, gravelly shallow and dry soils are not suitable. Under tropics flowering can be regulated through moisture availability while sub-tropics temperature is the determining factor.
Nutritive value: Fruits are important sources of minerals, fiber and vitamins, which provides essential nutrients for the human health. Nutritive value per 100 g of fruit is given below:

Proteins	Fats	Fibre	Calcium	Phosphorus	Oxalic Acid	Pectin	Total sugars
2.0 g	2.0 g	2.0 g	55.0 mg	275 mg	250.0 mg	4.5 %	3.55 g

(Hosakatte et al. 2019)

Medicinal importance and ethnobotanical uses:

- The fruits are used as astringent, anthelmintic, diuretic, demulcent and expectorant.
- The mucilage in the fruit is used for treating cough and diseases of the chest, uterus, urethra etc. and has laxative property.
- The kernels of the fruit are a good remedy for ringworms.
- The decoction of leaves is used in cough and cold.
- The bark along with pomegranate-rind is given for dysentery. The decoction of the bark is found useful in calculous infections, strangury, catarrh, dyspepsia and fever.
- The raw fruits are preserved in the form of pickle and also cooked as vegetable.
- Ripe fruits are used for preparing liquors. Lasora pulp is a rich source of pectin and could be utilized for making jams and jellies.

4. Phalsa (*Grewia subinaequalis* DC syn. *Grewiaasiatica* L.)

Phalsa is one of the oldest known fruits in India. Phalsa is a member of family Tiliaceae. It is widely cultivated in tropical and sub-tropical parts of India, Pakistan, Bangladesh, Thailand and Philippines. Plants are drought hardy and can be grown successfully in the hot and dry plains having distinct summer and winter. Thus, it is the most suited short duration crop in arid parts of the country even under the extreme summer conditions. Perishable nature of fruits, small size and repeated harvesting restricts its popularity. The plantations are mainly confined to Punjab, Haryana, Rajasthan, Madhya Pradesh and Uttar Pradesh. Small scale cultivation of this crop is seen in Maharashtra, Gujarat, Andhra Pradesh, Bihar, West Bengal and Karnataka.

Synonyms : Falsa, Dhamin, Parusha, Shukri, Dhaman
Life form : Shrub or Small tree
Flowering : February – March
Fruiting : April – May
Propagation : Seed, Hardwood cuttings, Air layering, Softwood grafting.
Habitat: The phalsa is a fruit of warm climate and produces well upto an elevation of 1000 m. It grows under subtropical climate but does best in regions with distinct winter and summer. It sheds leaves in winter. In tropics, continuous and irregular crop of poor quality is a common sight but fruiting can be monitored through moisture regulation. Plants can tolerate freezing temperature for a few days and high as 44^{o} C.Clear weather during fruiting enhances the quality of fruits. Photoperiodically, it is a short day plant. Plants are moderately sensitive to salinity and calcareous soils. Well drained loamy soils are preferred for its cultivation.
Nutritive value: Ripe fruits are reddish brown and sub acidic in taste. The fruits are good source of vitamin A and C. The fruits are rich in carbohydrates, calcium, phosphorus, iron and carotene. Nutritive value per 100 g of fruit is given below:

Calories	Protein	Vitamin A	Vitamin C	Carbohydrates	Calcium	Phosphorus	Potassium
90 K cal	1.57 g	16.11 ug	4.38 g	21.1 g	136 mg	24.2 mg	372 mg

(R S Khan et al. 2019)

Medicinal importance and ethnobotanical uses:

- The fruits acts as aphrodisiac, tonic, alley thirst, cure inflammation, burning sensation, fever, heart and blood disorders.
- The bark is used for treatment of diarrhea. Barks of root are utilized in treatment of rheumatism.
- The phalsa seeds yield approximately 5% bright yellow oil which contains stearic acid (11%), palmitic acid (8%), oleic acid (13.5%) and linoleic acid (64.5%).
- Fruits have a cooling effect and are used for making excellent juice and squash.

5. Kaphal (*Myricaesculenta*)

It is a medium to large woody,evergreen, dioecious tree about 12-15 m in height. The male and female trees are separate and have almost similar appearance. Pistillate flowers are small, sessile, solitary and bracteates, sepals and petals are either absent or not visible, inflorescence (catkin), while inflorescence of staminate flowers is compound raceme. Tree yields a drupe fruit, red to dark brown in color, ellipsoidal or oval in shape having sweet or sour taste containing ovoid shaped, smooth surface light brown colored seed with oily taste. It is native to India and widely distributed in the

foothills of mid Himachal Pradesh including Arunachal Pradesh, Sikkim, Manipur, UttranchalandLushai Hills of Meghalaya

Synonyms : Box myrtle, krishnagarbha, kaiphal, kirishivani.
Life form : Medium sized tree
Flowering : February – Apil
Fruiting : May – July
Propagation : Seeds, Suckers, cuttings (July – August)
Habitat: This plant performs well in sub-tropical to sub- temperate areas. Itis found in hilly regions of northern India and Nepal especially in the regions of Garhwal and Kumaon of Uttarakhand, southern Bhutan and western Nepal especially at elevations of 900–1,800 m (3,000–6,000 ft). It is also found at elevations below 1,500 m (4,900 ft) in the midhills of Nepal.
Nutritive Value: The edible portion of the fruit is its pulp, which is 75.4 per cent of the whole fruit. It contains 80.6 per cent moisture. The total soluble solids content of the fruit is 19.5 per cent. The juice content of the fruit is 40 percent.Nutritive value per 100 g of fruit is given below:

Protein	Total sugars	Acidity	Vitamin C	Energy	Potassium	Magnesium	Carbohydrates
0.97 g	12.6 %	3.68 %	4.12 mg	123.79 Kcal	1.98 mg	8.40 mg	16.13 mg

(P. Sood and R. Shri, 2018**)**

Medicinal importance and ethnobotanical uses:

- Bark is most important part used in the Indian systems of medicine. The bark is considered as astringent, heating and stimulant by Ayurveda and resolvent, carminative and tonic by Unani practitioners.
- An oil prepared from the bark is dropped into the ears in earache. Pessary made of the bark are used to promote menses.
- The seed oil is useful for massage in body ache and used to treat ear discharge. An effective Ayurveda preparation, Kaas-HarChurna is also prepared from this plant which is used in cough and cold.
- Fruit possess antioxidant properties and are used in the preparation of refreshing drinks.
- White waxy coating over fruits is used for making candles, soaps.

6. Karonda (*Carissa carandus*L.)

Carissa carandas is a species of flowering shrub in the family Apocynaceae. It produces berry-sized fruits. It flourishes well in regions with high temperatures. Thus, it is found in abundance in Western Ghats of Konkan region in the western coastal states of Maharashtra and Goa. Nevertheless, it grows naturally even in the temperate conditions of Siwalik Hills of Himalayas in India and Nepal at elevations up to 1800 metres. It grows naturally in most South Asian countries like in the lowland rain forests of Sri Lanka and in other countries like Nepal, Afghanistan, and Bangladesh.

Synonyms : Kharnu, Garna, Karondhu, Conkerberry
Life form : Shrub
Flowering : March – May
Fruiting : June – September

Propagation : Seed, Air layering (June), Budding, Grafting (July - September)
Habitat: Karonda is a fruit plant of dry areas and is well adapted for arid tropics and sub tropics. It is a very hardy, drought-tolerant plant, can withstand high temperatures and thrives well in wide range of soils as a rainfed crop. Heavy rainfall and waterlogged conditions are not desirable. It can be grown on a wide range of soils including saline and sodic soils. It is most fruitful on deep, fertile, well-drained soil but if the soil is too wet, there will be excessive vegetative growth and lower fruit production.
Nutritive value: Fruits are astringent and are a good source of calcium, iron, essential vitamins and minerals. Nutritive value per 100 g of fruit is given below:

TSS	Acidity	Ascorbic Acid	Total Sugars	Reducing Sugars	Crude Protein	Iron	Calcium	Phosphorus
7.80 %	1.51 %	6.98 mg	3.96 %	3.15 %	2.82 %	6.2 mg	16.3 mg	24.7 mg

(Dalal et al, 2010)

Medicinal importance and ethnobotanical uses:

- The warm root decoction is recommended to cure lower abdominal pains during pregnancy. The roots are ground and applied on the wounds of cattle to kill worms.
- The fruit is a strong purgative and is used as one of the ingredients in some purgative preparations.
- The roots act as a repellent to snakes, and powdered roots mixed with water are poured into snake pits to ward off snakes.
- The bushes of this plant are used as live fences in the rural areas because of the thorns. These bushes are very hardy, drought-tolerant and grown even on very poor and rocky soils
- Different value added products can be made from karonda pulp such as Chutney, tart, pickle, squash, jam, jelly, preserve and candy

7. Bael (*Aegle marmelos*)

Bael is a woody plant of family Rutaceae and is native to India. The importance of bael fruit lies in its curative properties, making it one of the most useful plants of India. The bael has been known in India from prehistoric times. In Indian tradition leaves are sacredly offered to 'Lord Shiva'. Fruits are globose, rind gray or yellow, pulp sweet, thick yellow, orange to brown in color. Seeds are numerous and arranged in the cells surrounded by a slimy transparent mucilage having wooly hairs. Juicy is the edible part.The plant grows throughout the Indian peninsula as well as in Sri Lanka, Pakistan, Bangladesh, Burma and most of South-East Asian countries.
Synonyms : Wood apple, Bengal Quince, Sirphal, Bilpatri
Life form : Medium sized tree
Flowering : March – April
Fruiting : May –June (Next year)
Propagation : Seed, Suckers, Patch budding (June - July)
Habitat: Bael trees adapt successfully to a wide range of habitat from arid, semiarid to mesophytic conditions. It can be grown up to an altitude of 1219 meters above mean sea level and can tolerate temperatures as low as -8°C. Bael can be grown in any type of soil such as clay, sandy, water logged, unirrigated, alkaline or acidic,in the pH range of 5 to 10.

Nutritive value: Marmelosin is most probably the therapeutically active principle compound of bael fruit. Bael fruit is highly nutritious and constitutes large content of riboflavin. Nutritive value per 100 g of fruit is given below:

Energy	Riboflavin	Protein	Mineral	Fibre	carbohydrates	Calcium	Phosphorus
137 Ecals	1.19 mg	2 g	2 g	3 g	32 g	85 mg	50 mg

(Sawale et al, 2018**)**

Medicinal importance and ethnobotanical uses:

- Half ripe fruits are mildly astringent and are used to cure diarrhea, dysentery, hepatitis, dyspepsia, tuberculosis and good for brain and heart.
- Ripe fruits are astringent, aromatic, cooling and best laxatives. Fruits possess wide range of therapeutic effects that includes antioxidant, inhibition of lipid peroxidation, free radical scavenging, antiviral, gastro protective, antibacterial, hepatoprotective, anti-ulcerative colitis, cardio protective, anti- diabetic and radio protective effects.
- Marmelosin present in the pulp acts as a laxative and diuretic. In excess intake, it lowers the respiration rate, depresses the heart action and causes sleepiness.
- Riboflavin rich fruit is used for the preparation of different products like squash, candy, slab, toffee, pulp powder and nectar
- Fruit pulp is used for the preparation of delicacies like puddings and murabba.
- Seeds and leaves have different pesticidal and detergent actions.

8. Wild Ber (*Zizyphusjujuba* Mill)

Ber is called the king of arid fruits. It belongs to family Rhamnaceae and excessively distributed in tropical and sub-tropical regions of northern hemisphere. It is an ideal choice for places where other crops cannot be grown due to lack of irrigation facilities or adverse climatic and soil conditions. It is a spiny, evergreen shrub with spreading crown, stipular spines and many drooping branches. Fruit vary in shape, size and can be oval, obovate, oblong or rounddepending on the variety. Ber is native to central Asia and found growing almost in all parts of India.In India the tree is sacred to Shiva and is known as “the tree which removes sorrow”, perhaps because of its sedative properties. It was depicted in the Ramayana so has been known for centuries in the subcontinent and was not a recently introduced species

Synonyms : Indian Jujube,Ragepandu, Bare Hannu, Dunks, Badri, Malhe, JharBeri
Life form : Shrub
Flowering : June – September
Fruiting : November – February
Propagation : Seed, Shield or T budding (July - August)
Habitat: Ber is found to be growing under varying climatic conditions throughout the India. However below freezing point can be injurious to fruits as well as young plants. Ber attains dormancy during May – June when it is very hot in the northern plains. Plants are hardy, possess tap root system and can be grown in wide range of soils including infertile and porous soils unsuitable for different crops. However, plants thrive well in sandy loam soils with neutral or alkaline reactions.

Nutritive value: The ber fruits are rich in nutritive value. The composition of ber fruits varies differently with cultivar and agroclimatic zone. Nutritive value per 100 g of fruit is given below:

Moisture	Proteins	Carbohydrates	Fats	Fibres	Ascorbic acid	Energy	Carotenoid
64.39 %	2.31 g	9.4 g	0.355 g	3.73 g	183.4 g	48.8 kcal	348.55 mg

(Kavitha et al. 2014)

Medicinal importance and ethnobotanical uses:

- Ber fruits are used for weight gaining, improving muscular strength and as an immuno-stimulant for increasing physical stamina.
- Bark and leaves are used to treat measles and chicken pox. Decoction of shade dried young tender leaves helps in treating scurvy, lowering blood sugar level and diabetes. The paste of leaves is applied on pimples, abscesses, acne, carbuncles and boils
- Seedlings are used as rootstock for commercial scion varieties.

9. Wild / Himalayan fig (*Ficuspalmata*)

Fig is a deciduous tree growing up to 5 metres tall.The plant is often gathered from the wild for its edible fruits and young shoots. It is often cultivated for its fruit in India and Ethiopia and has been recommended for commercial cultivation. The fruits are often sold in local markets in the Himalayas. This plant is native to India and occurs in sub-tropical to sub-temperate areas of Himachal Pradesh. The species grows in boundaries/bunds of cultivated fields, wastelands and near domesticated areas.

Synonyms : Fegra, Dagla,Khasra, Dudha, Bedu
Life form : Small tree
Flowering : March – April
Fruiting : June – July
Propagation : Seeds, Cutting (January-February), Air layering (June), Cleft / Bark grafting.
Habitat: Wild fig is a plant of warm temperate to subtropical zones and can grow up to an elevations of 1000 m or more in the tropics. Young growthis frost-tender.Plants requires a well-drained medium to light loam and some lime rubble incorporated into the soil. A heavy wet soil tends to encourage plant growth at the expense of fruiting. They grow in areas where the climate is too wet for common figs, since it fruits during the monsoon season in the Himalayas. However, wild figs probably requires the fig-wasp in order to pollinate the flowers and so is unlikely to fruit in areas that are too cold for the fig-wasp to survive.
Nutritive value: Figs are an excellent source of crude fibre, phytosterols, minerals, anthocyanins, carotenoid, and polyphenols. Nutritive value per 100 g of fruit is given below:

Protein	Phenols	Ascorbic Acid	Pectin	Fibre	Fat	Anthocyanins	Carbohydrates	Energy
1.35 %	513 mg	3.67 mg	0.20 %	18.9%	1.07%	0.181	19.8 mg	99.8 kcal

(Kajal et al. 2018)

Medicinal importance and ethnobotanical uses:

- The fruit is demulcent, emollient, laxative and poultice. It is used as a part of the diet in the treatment of constipation and diseases of the lungs and bladder.
- The sap is used in the treatment of warts. The latex of the plant is used to take out spines lodged deeply in the flesh
- The plant is used as a rootstock for the common fig (*Ficuscarica*).
- The pliable wood has been used for making garlands, hoops, ornaments etc.
- Unripe fruits are boiled, water removed by squeezing and eaten as fried vegetables (Bhruni) or as riata (mixed with curd). Thin branches are used as perforated sieves for steam cooking of different preparations like siddu/momos.

10. Jackfruit (*Artocarpus spp.*)

Jackfruit considered to be the "poor man's food" belongs to the Moraceae family. It is native to India and seen abundantly in the Western Ghats, a biodiversity spot of India.Jackfruit is the national fruit of Bangladesh. Many species are found in tropical and sub- tropical Himalayas, in Himachal Pradesh, it is sparsely cultivated or naturalized as an escape in the districts of Hamirpur, Kangra, Una and Shimla. Jackfruit is the largest tree borne fruit in the world weighing 3–36 kg. Jackfruit possess cauliflorous bearing habit(fruits are borne on trunk and branches). Short, stout flowering twigs emerge from the trunk and branches. The tree is monoecious, tiny male flowers are borne in oblong clusters while the female flower clusters are elliptic or rounded. The fruit rind is composed of numerous cone like points attached to rubbery pale yellow or whitish wall.

Synonyms : Dheu, Kathal, Phanas,Lakucha, Lakudi, Monkey Jack
Life form : Tree
Flowering : March – April
Fruiting : June – September
Propagation : Seed, Air layering, Inarching, Forkert and Patch Budding (February – September)
Habitat: Jackfruit is adapted only to humid tropical and near-tropical climates. In early life, plants are sensitive to frost and cannot tolerate drought. In India, it thrives in the Himalayan foothills and in the south, to an altitude of 1500 m. Quality of fruits deteriorates in higher altitudes. It can grow in wide variety of soils though it flourishes well in rich, deep alluvial soil. Sub soil drainage congestion, rise in water table or flood severely damage the trees and may lead to death.
Nutritive value: The fruit contains simple sugars (fructose and sucrose) and is a rich source of vitamin A. Nutritive value per 100 g of fruit is given below:

Protein	Vitamin A	Carbohydrate	Total sugars	Calcium	Potassium	Phosphorus	Sodium
1.5 g	550 IU	25.4 g	20.6 g	37 mg	400 mg	41.0 mg	40 mg

(Ranasinghe et al. 2019**)**

Medicinal importance and ethnobotanical uses:

- Jackfruit possess antipyretic, anti-inflammatory, antibacterial, antioxidant, antidiabetic properties.
- Ripe fruit acts as vata-pitta nashak, kaphkarak, aphrodisiac and also improves taste and appetite while unripe fruit treats blood disorders and eye troubles.

- Jackfruit is used as vegetable or to make stir-fries, curries, cake, candies, ice cream, Jam, soup and Jellies.
- The heated latex is employed as household cement for mending earthenware's and to caulk boats and holes in buckets.
- Leaves are excellent absorbents and are used to remove dye from the aqueous solutions.

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Polyamines forms, biosynthesis and metabolism in plants

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Polyamines are low molecular mass polycations found in all living organisms. In plants, they have been implicated in a wide range of biological processes, including growth, development, biotic and abiotic stress responses. Interest has been increasing during the last 30 years in the naturally abundant polyamines *putrescine* (diamine), *spermidine* (triamine) and *spermine* (tetramine), which were demonstrated to be involved in a large number of cellular processes. The diamine putrescine (Put), the triamine spermidine (Spd) and the tetramine spermine (Spm) are the main polyamines (PAs) found in all living cells. They are aliphatic nitrogen compounds positively charged at physiological pH. This property allows PAs to interact with negatively charged macromolecules as DNA and RNA, proteins and phospholipids and in this way they are involved in the regulation of physical and chemical properties of membranes, nucleic acids structure and functions and modulation of enzyme activities (Galston and Kaur Sawhney, 1990). Polyamines are implicated in a wide range of regulatory processes such as promotion of growth, cell division, DNA replication and cell differentiation (Evans and Malmberg, 1989).

Investigations into plant polyamines at a molecular level have led to isolation of a number of genes encoding polyamine biosynthetic enzymes from a variety of plant species in recent years, molecular and genomic studies with mutants and transgenic plants having no or altered activity of enzymes involved in the biosynthesis of polyamines have contributed to a better understanding of biological functions of polyamines in plants. The levels of endogenous polyamines can be increased by application of exogenous polyamines, which has been attempted before or during stress. Exogenous application of polyamines could preserve plant cell membrane integrity, minimize growth inhibition caused by stress, moderate expression of osmotically responsive caused by stress, moderate expression of osmotically responsive genes and increase activities of antioxidant enzymes. In another approach treatment with biosynthesis inhibitors can reduce endogenous polyamine resulted in stress sensitive phenotype. It is hard to identify the contribution of polyamine accumulation in infected organs as it is present both in plants and pathogenic fungi. The possibility of control of

fungal plant diseases through specific inhibition of polyamine biosynthesis is most excited and for reaching development.

FORMS AND OCCURRENCE OF POLYAMINES

Polyamines, the low molecular weight nitrogen containing aliphatic compounds, are positively charged at physiological pH due to presence of amino groups and act as polycations, with charges distributed along a flexible carbon chain. They occur in free or conjugated forms. Polyamine conjugates with phenolic acids are widespread in higher plants. Polyamines are also bound to some macromolecules like proteins and nucleic acids. The conjugates may act as storage forms of polyamines from which free bases may be released and transported as and when required. The level of polyamines in plant cells depends on their biosynthesis, degradation, conjugation, transport and conversion to other metabolites.

Stress-induced PA accumulation and their protective function against biotic and abiotic stresses are of special interest. The concentrations of PAs in the plant (10-9 –10-5 M) are much higher than those of endogenous phytohormones (10-13– 10-7 M). The total PA concentration and the ratios between individual PAs vary markedly in dependence on plant species, organ, and tissue, and also on the developmental stage. The total PA concentration and the ratios between individual PAs vary markedly in dependence on plant species, organ, and tissue, and also on the developmental stage. The distribution patterns of PAs may be related to their unique functions. Polyamines show tissue- and organ-specific distribution patterns in plants. For example, the most abundant PA in leaves was found to be Put, and its levels were three times higher than those of Spd and Spm, whereas Spd was found to be the most abundant PA in other organs. Different types of PAs also show different localization patterns within cells. In carrot cells, Put was found to accumulate in the cytoplasm and Spm in the cell wall.In general, more vigorous plant growth and metabolism is associated with greater PA biosynthesis and higher PA contents. In higher plants, PAs are predominantly present in their free form. The most common PAs in higher plants are Put, Spd, Spm, thermospermine (Tspm), and cadaverine (Cad)

FUNCTIONS OF POLYAMINES

Biochemical effects of PAs have been unraveled in many physiological processes, primarily in stability and function of proteins and nucleic acids partly due to their positive charge that enables them to electrostatically interact with polyanionic molecules inside the cell. Polyamines correlate with numerous vital biochemical functions, including protein regulation, regulation of chemiosmosis and photoprotection in chloroplasts, ATP synthesis, ion channeling, membrane fluidity, and control of N/C balance.

Biosynthesis of polyamines

The initial biosynthesis of PAs is executed by two enzymatic steps including the rate limiting enzymes, the arginine decarboxylase (ADC) or ornithine decarboxylase (ODC), where they catalyze the decarboxylation of arginine or ornithine to Put, respectively. ADC and ODC are encoded in the genome of many plants, and the arginine pathway is the main Put biosynthesis route in plants. Interestingly, ODC is not present in the model plant Arabidopsis thaliana, indicating that the ornithine pathway might be not essential for normal growth of plants. The activities of ADC and ODC can be inhibited by irreversible competitive inhibitors difluoromethylarginine (DFMA) and difluoromethylornithine (DFMO), respectively (Grossi et al. 2016; Yamamoto et al. 2017). Spd and Spm are derived from Put via sequential addition of aminopropyl groups, which are donated by the methionine derivative that are produced by S-adenosylmethionine decarboxylase (SAMDC). Polyamines are further metabolized by oxidation and conjugation with other molecules.

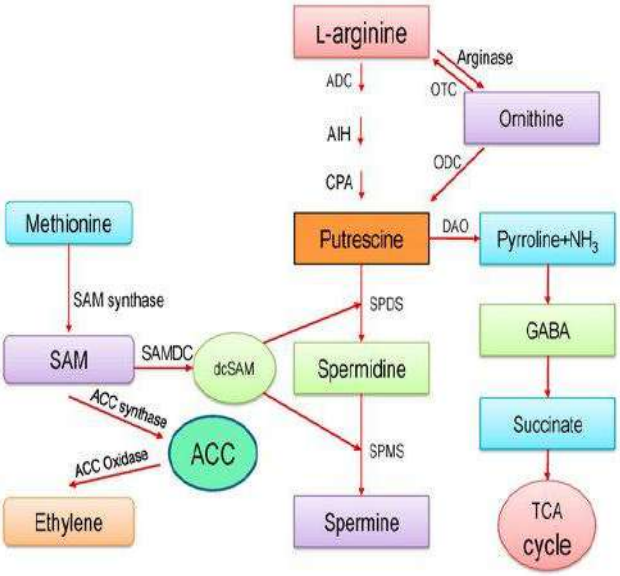

Figure1. Biosynthesis pathway of polyamines in plants. ADC: arginine decarboxylase; AIH: agmatine iminohydrolase; CPA: N-carbamoylputrescine amidohydrolase; SPDS: spermidine synthase; SPMS: spermine synthase; OTC: ornithine transcarbamoylase; ODC: ornithine decarboxylase; DAO: diamine oxidase; GABA: γ -aminobutyric acid; SAM: *S*-adenosylmethionine; SAMDC: S-adenosylmethionine decarboxylase; dcSAM: decarboxylated *S*-adenosylmethionine; ACC synthase: 1-aminocyclopropane-1-carboxylic-acid synthase. Arrows represent the synthesis/conversion.

Catabolism of polyamine

Polyamines are catobolized by two enzymes, diamine oxidase (DAO) and polyamine oxidase (PAO) (Cona et al.2006). DAO is responsible for catalyzing Put and converts it to Δ1 -pyrroline and the byproducts ammonia and H_2O_2; while, PAO produces Δ1 -pyrroline and 1,3-diaminopropane by degrading Spd or Spm (Bagni and Tassoni 2001). DAO is responsible for catalyzing Put and converts it to Δ1 -pyrroline and the byproducts ammonia and H_2O_2; while, PAO produces Δ1 -pyrroline and 1, 3-diaminopropane by degrading Spd or Spm. It is well known that H_2O_2 accumulates in plants under abiotic stresses. Therefore, H_2O_2 produced by DAO or PAO may be a crucial determinant for plants to survive under environmental stresses. Quinet et al. (2010) reported that PAO activities were higher in the roots of salt resistance plants than salt-sensitive ones under salt treatment, suggesting that PAs metabolism may play important roles for plants to resist salt stress. In addition, the metabolism of PAs is

related to the production of NO, which is an essential signaling component for plant growth. Therefore, the roles of PAs in plant growth and development and the mechanisms underlying their function can be explored by studying the relationship between PA metabolism and plant hormones, and the effects of PA metabolism on plant signalling substances.

Major Types of Agricultural Farming in India and Its Importance

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Agriculture is the science and art of cultivating plants and livestock. Agriculture was the key development in the rise of human civilization, whereby farming of domesticated species created food surpluses that enabled people to live in cities. The history of agriculture began thousands of years ago. Plants were independently cultivated in at least 11 regions of the world. Industrial agriculture based on large scale monoculture in the twentieth century came to dominate agricultural output, though about 2 billion people still depended on subsistence agriculture. Modern agronomy, plant breeding, and agrochemicals such as pesticides and fertilizers, and technological developments have sharply increased yields while causing widespread ecological and environmental damages. Environmental issues such as contributions to global warming, depletion of aquifers, deforestation, antibiotic resistance, and growth hormones in crop production are the major problems. Genetically modified organisms are widely used; although some are banned in certain countries.The major agricultural products can be broadly grouped into foods, fibres, fuels and raw materials. Food includes cereals, vegetables, fruits, oils, meat, milk, fungi, and eggs. Over one-third of the world's workers are employed in agriculture, second only to the service sector, although the number of agricultural workers in developed countries has decreased significantly over the centuries.

TYPES OF AGRICULTURE IN INDIA

Based on the nature of the land, climatic characteristics and available irrigational facilities, the farmers in India practice different types of farming:

Subsistence farming: This is one of the most popular farming techniques that can be seen in various parts of India and majority of the farmers along with his family cultivates grains for themselves or for sale at the local market because the yield may not be too high. The entire family works on the small scattered land and the traditional method of farm practices are done manually. They do not use fertilizers and high yielding varieties as they are poor. Historically and currently a difficult way of life,

subsistence farming is considered by many a backward lifestyle that should be transformed into industrialized communities and commercial farming throughout the world in order to overcome problems of poverty and famine. The numerous obstacles that have prevented this to date suggest that a complex array of factors, not only technological but also economic, political, educational, and social, are involved. An alternative perspective, maintains that the subsistence lifestyle holds the key to sustainability as human relationships and harmony with the environment. The ideas inherent in much of subsistence farming are cooperation, local, ecologically appropriate and positive attributes that must be preserved in our efforts to improve the lives of all people throughout the world.

Shifting Agriculture: This way of farming is widely used by tribal groups to grow crops. First, the land is obtained by clearing a forested area and then crops are planted for two to three years. While the land loses its fertility, another area of land is cleared and the crops are shifted there. The commonly grown crops in this type of farming are dry paddy, maize, millets, and vegetables. This practice is known by a different name in different regions of India. Shifting cultivation, also known asslash / Jhum cultivation and burn agriculture and regarded as the first step in transition from food gathering/hunting to food production, is still prevalent on a wide scale in the north eastern region and some other parts of India. The characteristics of the system are rotation of fields rather than a crops, land clearing by burning, absence of draft animals and manuring, use of human labor only, use of dibbling stick or hoe, and short periods of cropping alternating with long fallow periods. The system of cultivation is, however, a peculiar way of life among certain tribes and cannot be isolated easily from the socioeconomic aspects of land tenure, cooperative efforts of clans, and the traditional culture. The shifting control programms are yet to make a dent on the overall problem and their impact in respect of weaning the people away from the shifting cultivation and improvement of the socioeconomic condition is also yet to be assessed.

Plantation Agriculture: Plantations are only capable of producing a single crop which takes a long time to grow. Plantation agriculture is practiced in Kerala, Assam, Karnataka, and Maharashtra. For example, rubber, tea, coffee, cocoa, spices, coconut and fruit crops like apples, grapes, oranges, etc. are grown by plantation agriculture. Since it is a capital intensive process, it requires good managerial ability, technical knowhow, and advanced machinery, fertilizers, irrigation, and transport facilities. It is export oriented agriculture and grown for more than two years. It is a form of commercial farming where crops are grown for profit only. Large land areas are needed for this type of agriculture. Countries that have plantation agriculture usually experience high annual temperatures and receive high annual rainfall. The characteristic features of this type of farming are large estates or plantations, large capital investment, managerial and technical support, scientific methods of cultivation, single crop specialisation, cheap labour, and a good system of transportation which links the estates to the factories and markets for the export of the products.

Intensive Agriculture: In areas where irrigation facilities are possible, the farmers use fertilizers and pesticides on a large scale to bring their land under a high yielding variety of seeds. It is also known as industrial agriculture. It involves a higher use of inputs such as capital and labor per unit land area. This is where it differs from traditional agriculture where the inputs per unit land area. It is a type of agriculture, both of crop plants and of animals, with higher levels of input and output per cubic unit of agricultural land area. It is characterized by a low fallow ratio, higher use of inputs such as capital and labour, and higher crop yields per unit land area. Most commercial agriculture is intensive in one or more ways. Forms that rely heavily on industrial methods are often called industrial agriculture, which is characterised by innovations designed to increase yield. Techniques include planting multiple crops per year, reducing the frequency of fallow years, and improving cultivars. It also involves increased use of fertilizers, plant growth regulators, and pesticides and mechanised agriculture, controlled by increased and more detailed analysis of growing conditions, including weather, soil, water, weeds, and pests. This system is supported by ongoing innovation in agricultural machinery and farming methods, genetic technology, techniques for achieving economies of scale, logistics, and data collection and analysis technology.

Wet Agriculture: Wet Farming is practiced in the areas of alluvial soils where annual average rainfall is more than 200cm.Here; more than one crop is grown in a year because enough amount of moisture in the soil is available. Many areas of India are affected by heavy monsoon rains and subsequent flooding. This is suitable in all the well irrigated areas like those in north east India and the Western Ghats. Rice, jute, and sugarcane are cultivated in such mode of agriculture.

Terrace Agriculture: . Terrace farming is a method of farming whereby "steps" known as terraces are built onto the slopes of hills and mountains and the land is used in the same way as in permanent agriculture. Due to the scarcity of the availability of flat land, terraces are made to provide a small patch of level land. Soil erosion is also checked due to terrace formation on hill slopes. Terrace farming is a type of farming that was invented by the *Inca* people who lived in the South American mountains. Apart from rice cultivation, terraces are also used to grow rice, potatoes, and maize. When it rains, instead of rain carrying away the soil nutrients and plants down the slope, they flow to the next terrace. Every step has an outlet which channels water to the next step. This helps in keeping some areas dry and others wet. On very high altitudes, other crops apart from rice can be grown. This is because rice does not do well on high altitudes. There are two types of terracing known as graded terracing and level terracing. A graded terrace may have either constant or variable grades along its length. On the contrary, the level terraces follow a contour line and are best suited for permeable soil.

This leads to the growth of healthy crops. Secondly, it prevents the carrying away of plants by the heavy flowing rivers of water. Sometimes rain water carries away the crops leading to low crop yield. Thirdly, terraces help in reduction of soil erosion and water loss. The fourth benefit of terrace farming is that it has made the idle hillside land

become productive. Lastly, terraces trap rainwater allowing the people to engage in cultivation of water intensive crops such as rice. Terrace farming is able to turn the moist idle land into productive farms leading to high food security in the world. It also helps in retaining the soil nutrients in the farms. Terrace farming can lead to rainwater saturation. This is dangerous since it causes the overflow of water during the rainy season. The consequence of overflowing water is that it causes more dangerous water runoffs. Terraces may also result in mudslides if not well managed. Another limitation of terrace farming is that there's need for huge inputs of labor to construct and maintain the terraces. Hence it is expensive as it is labor intensive. However, it can be cheap if there's access to cheap labor. It also leads to the reduction in soil quality due to the leaching process.

IMPORTANCE OF AGRICULTURE IN INDIAN ECONOMY

Though all industries have been playing an important role in Indian economy, major part of contribution in the development of Indian economy is through agriculture.

1. Agricultural influence on national income:

The contribution of agriculture during the first two decades towards the gross domestic product ranged between 48 and 60%.Growth of agriculture sector has been fluctuating: it increased from -0.2% in 2014-15 to 6.3% in 2016-17, and then declined to 2.9% in 2018-19. Gross fixed capital formation in agriculture has decreased from 17.7% in 2013-14 to 15.2% in 2017-18. The contribution of agriculture to the GVA has decreased from 15% in 2015-16 to 14.4% in 2018-19. The decline was mainly due to decrease in share of GVA of crops from 9.2% in 2015-16 to 8.7% in 2017-18. Almost 89% of groundwater is extracted for irrigation. Further, crops such as paddy and sugarcane consume more than 60% of irrigation water available in India, which reduces water availability for other crops. In the year 2001-2002, this contribution declined to only about 26%. From the very beginning, agriculture is contributing a major portion to our national income. In 1950-51, agriculture and allied activities contributed about 59 per cent of the total national income. Although the share of agriculture has been declining gradually with the growth of other sectors but the share still remained very high as compared to that of the developed countries of the world. For example, the share of agriculture has declined to 54 per cent in 1960-61, 48 per cent in 1970-71, 40 per cent in 1980-81 and then to 18.0 per cent in 2008-09 when compared with other countries.

2. Agriculture plays vital role in generating employment:

In India at least two-thirds of the working population earn their living through agricultural works. In India other sectors have failed generate much of employment opportunity the growing working populations. In India over two-thirds of our working population are engaged directly on agriculture and also similarly depend for their livelihood. According to an estimate, about 66 per cent of our working population is engaged in agriculture. Thus the employment pattern of our country is very much

common to other under-developed countries of the world. Agriculture provides employment to not only the adult males of a households but also to women on the households .Women work extensively in production of major grains and millets, in land preparation, seed selection and seedling production, sowing, applying manure, weeding, transplanting, threshing, winnowing and harvesting

3. Agriculture makes provision for food for the ever increasing population:

Due to the excessive pressure of population labour surplus economies like India and rapid increase in the demand for food, food production increases at a fast rate. The existing levels of food consumption in these countries are very low and with a little increase in the capita income, the demand for food rise steeply. Therefore, unless agriculture is able to continuously increase it marketed surplus of food grains, a crisis is like to emerge. Many developing countries are passing through this phase and in a bid to ma the increasing food requirements agriculture has been developed. Agriculture is the only major source of food supply as it is providing regular supply of food to such a huge size of population of our country. It has been estimated that about 60 per cent of household consumption is met by agricultural products.

4. Contribution to capital formation:

There is general agreement on the necessity capital formation. Since agriculture happens be the largest industry in developing country like India, it can and must play an important role in pushing up the rate of capital formation. If it fails to do so, the whole process economic development will suffer a setback. Agriculture is one of the major sources of revenue to both the Central and State Governments of the country. The Government is getting a substantial income from rising land revenue. Some other sectors like railway, roadways are also deriving a good part of their income from the movement of agricultural goods.

5. Supply of raw material to agro-based industries:

Agriculture supplies raw materials to various agro-based industries like sugar, jute, cotton textile and vanaspati industries. Food processing industries are similarly dependent on agriculture. Therefore the development of these industries entirely is dependent on agriculture.

6. Market for industrial products:

Increase in rural purchasing power is very necessary for industrial development as two-thirds of Indian population live in villages. After green revolution the purchasing power of the large farmers increased due to their enhanced income and negligible tax burden.

7. Influence on internal and external trade and commerce:

Indian agriculture plays a vital role in internal and external trade of the country. Internal trade in food-grains and other agricultural products helps in the expansion of service sector. Indian Agriculture is playing a very important role both in the internal

and external trade of the country. Agricultural products like tea, coffee, sugar, tobacco, spices, cashew-nuts etc. are the main items of our exports and constitute about 50 per cent of our total exports. Besides manufactured jute, cotton textiles and sugar also contribute another 20 per cent of the total exports of the country. Thus nearly 70 per cent of India's exports are originated from agricultural sector. Further, agriculture is helping the country in earning precious foreign exchange to meet the required import bill of the country.

8. Contribution in government budget:

Right from the First Five Year Plan agriculture is considered as the prime revenue collecting sector for the both central and state budgets. However, the governments earn huge revenue from agriculture and its allied activities like cattle rearing, animal husbandry, poultry farming, fishing etc. Indian railway along with the state transport system also earn handsome revenue as freight charges for agricultural products, both-semi finished and finished ones. The government allocated 2.83 lakh crore rupees for agriculture and allied activities, irrigation and rural development in 2020-21 budget. comprehensive measures for 100 water-stressed districts in the country. Agricultural credit target has been set up at 15 lakh crore. "Pradhan Mantri Kisan Urja Suraksha evem Utthan Mahabhiyan (PM KUSUM) to be expanded to provide 20 lakh farmers in setting up standalone solar pumps.Farmers who have fallow or barren land will be helped to set up solar power generation units and also sell surplus power to the solar grid and also make living out of even barren land.India encourage balanced use of all fertilizers, a necessary step to change the incentive regime which encourages excessive use of fertilizers.

9. Need of labour force:

A large number of skilled and unskilled labourers are required for the construction works and in other fields. This labour is supplied by Indian agriculture. It is an established trend that as an economy matures, there is a movement of agricultural workers from low productivity agriculture to higher productivity sectors. However in India, the trend has not been limited to just declining share of agriculture in total employment but also has led to a significant decline in absolute number of people employed in the agricultural sector. A comparison across two time periods, 2004-05 and 2011- 12, indicates that while there was an increase in the size of the total workforce in the country, the size of the agricultural workforce reduced by 30.57 million people. The share of agricultural workforce in total workforce declined from 56.7% to 48.8% in the same period. This brings to the fore that fewer people are being added to the workforce in agriculture and highlights the net migration to other sectors. Factors such as higher remuneration and growth of opportunities in alternate sectors coupled with the relatively lower rise in wages in agricultural occupations as compared to other sectors have led to the migration of workforce away from agriculture which has resulted in labour shortage and consequent escalation of cost of cultivation.

Furthermore, government schemes like MGNREGA which have facilitated migration of labour to other segments need to be reformed. , availability of labour in agriculture crucially depends upon job creation in the non-farm sector, the pace of urbanization, social schemes and incentives in the rural sector and wages in the agriculture sector, besides certain social factors like children's education and status.

10. Greater competitive advantages:

Indian agriculture has a cost advantage in several agricultural commodities in the export sector because of low labour costs and self- sufficiency in input supply.

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Green Manuring: A practicable alternative source to supplement inorganic fertilizer

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ABSTRACT

In the current scenario, non-judicious use of fertilizers, increasing environment pollution and high cost of chemical fertilizers, demands for alternative sources to supplement inorganic fertilizers. There is a need of alternate and natural ways of nutrient replenishment to sustain agriculture. The nitrogen management is a primary concern for farmers because nitrogen is the nutrient required in larger quantities in most of the crops but it is also easily lost from the system. Integrating green manures with inorganic fertilizers has the potential to offer benefits to the different cropping systems. Thus, Green manuring is a good alternative practice for soil amelioration.

Key words: Green manuring, Soil fertility, Legumes

INTRODUCTION

Green Manuring

It is the incorporation of green manure crops usually belongs to leguminous family. It is the practice of incorporation of green manure crop in the soil either by raising them in the same field or plants grown elsewhere at the green stage before flowering and incorporated into the soil. The green manure crops should be buried in the soil at suitable time for their proper decomposition and to improve soil fertility and productivity. Legumes are largely used as green manure due to their symbiotic nitrogen fixing ability. Legumes are of two main types: Non-grain legumes (Sunhemp and Sesbania) and Grain legumes (Soybean, Cowpea, green gram & Black gram). Some non-legume plants are also used as green manure. These will not fix nitrogen but can be effective in adding organic matter to the soil and smothering weeds

OBJECTIVES OF GREEN MANURING

- Green manuring improves the nitrogen content in soil in a short period.
- It improves soil structure, physical properties, enhances soil properties.
- It adds organic matter in the soil

- It also helps in preventing soil erosion.

DESIRABLE QUALITIES OF A GREEN MANURE CROP

- Early establishment and high plant vigour.
- It should be tolerant to drought, shade, excess water and adverse temperature.
- It should possess early onset of nitrogen fixation.
- It should have deep root system which can open the subsoil and tag nutrients from lower regions for plant nutrients.
- The plants should be of a leafy habit and capable of producing heavy tender growth in its life cycle.
- Easy to incorporate and should be quickly decomposable.
- It should be tolerant to pests and diseases.

Abundant availability of water and sufficient fallow time before the transplanting of rice crop makes the green manuring most suitable for rice –wheat cropping system. Harvest and thresh fully ripened wheat crop. Irrigate the field and sow 20kg seed per acre of Dhaincha and Sunhemp or 12 kg seed/acre of cowpea up to the end of april. Bury 6-7 weeks old Dhaincha/Sunhemp/Cowpea,1-2 days before transplanting of paddy. This will help in saving of about 25 kg N/acre for rice besides maintaining the soil health. In maize- wheat sequence, green manure crops also helps in reducing run-off, improving soil carbon and in producing N-rich biomass.

FACTORS AFFECTING EFFECTIVENESS OF GREEN MANURING

The factors which affects the growth and development of green manure crop will automatically effect the effectiveness of green manure crops.

***Sowing time*:** It is always advisable to sow green manure crops much before/at least 30to 45 days before the onset of monsoon so that turning and ploughing may be done during active rain period during the period of decomposition.

Seed rate: Seed rate of 1 or 1.5 times more than normal by broadcasting can be used for raising of green manure crops. More seed rate,more is the biomass production.

***Fertilization of green manure crops*:** Green manure crops should be fertilized with phosphatic fertilizers for boosting growth and development of rhizobium bacteria which ultimately will increase nitrogen fixation. Green manures have benefits for soil N dynamics by recovering residual mineral N in soil, by fixing N from the atmosphere for leguminous green manures and leads to subsequent crop N nutrition. The green manures with lower C/N ratios quickly decompose rapidly and have a rapid impact on soil physical properties and on biological activity. Management techniques such as timing of incorporation of green manures (flowering, high maturity) can influence their decomposition, N release into soil and N uptake by subsequent crops.

ADVANTAGES OF GREEN MANURING

- It adds organic matter in the soil which stimulates microbial activities in the soil.

- The green manure crops remove nutrients from deeper layers and during decomposition release these nutrients in upper layers. Thus it is useful in recycling of nutrients.
- When green manure crops like Sunhemp, Dhaincha,etc are grown and incorporated in the soil, they add significant quantities of nitrogen in the soil.
- It increases the water holding capacity of the soil.
- It also checks soil erosion, aeration, soil structure, etc.

CONSTRAINTS OF GREEN MANURING

- Unavailability of quality seeds.
- In rainfed areas, proper decomposition is not there.
- Benefits are not directly visible as in case of inorganic fertilizer nitrogen.

CONCLUSION

To minimize the use of chemical fertilizers and to reduce dependence on chemical sources, there is need of alternative sources and green manuring is the ideal one. Green manure provides good quantity of organic matter, increases microbial biomass and recycles nutrients into the soil. It not only improves soil quality, but also fixes atmospheric nitrogen in the soil if legumes are considered. Thus, it restores soil fertility and improves soil health.

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Use of antibiotics in livestock farming: Effect on public health and its alternative

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Abstract

The livestock sector contributes a lot by providing food and income source for millions of people, worldwide. In India, livestock employs 8.8% of the population. It contributes 4.11% to GDP and 25.6% of total agriculture GDP. The livestock sector is facing prodigious pressure to meet the demand of increasing the human population for animal protein (like meat, milk, egg, etc.). Antibiotics are being used in the livestock sector as growth promoters to increase animal production so that demand and supply of animal protein can be maintained.However, antibiotics have a harmful impact on public health such as antibiotic residues in animal products, the development of antibiotic-resistant bacteria, the emergence of fungal infections, immunosuppression, etc. So, there is a need to develop other alternatives that are as effective as antibiotic growth promoters to overcome the development of livestock-associated antimicrobial resistance and other health-related issues of humans without affecting growth performance and production value of the livestock.

Key Words: Antibiotics, Antimicrobial resistance, Growth promoter, Livestock farming

INTRODUCTION

The antibiotic discovery was a breakthrough in mankind's history. Antibiotic is like a magic bullet that kills pathogenic bacteria without harming the body cell. Antibiotics have saved countless lives from infectious diseases.Antibiotics not only have the therapeutic potential against bacteria but also have growth-promoting effects on animals when it is used below the therapeutic dose. Its mechanism of growth promotion is unknown. Demand for animal protein is increasing day by day due to an increase in the human population and also a shift in the food habits of people from vegetarians to non-vegetarians, globally. So,there is prodigious pressure on animal husbandry to increase animal production to meet the increasing demand for animal food. To do so, antibiotic growth promoters (AGPs)are being used in animalfarming especially in

poultry, swine, and cattle for more than five decades and still in use. In a study, it is reported that the use of antibiotics will increase by 82% by 2030 (Van Boeckel et al., 2005).For many years, the positive aspect of the use of antibiotics in food animals wasnoted withoutundermining its negative consequences. But experts in the field of microbiology and infectious diseases faced antibiotic resistance among bacteria and raised questions about their impact on human health (Levy, 2002). Many studies found that farms using AGPs had more resistant bacteria in the intestinal floras of the farmworkers and farm animals than in those for similar people and animals on farms not using AGPs. A prospective *in vivo*/*in situ* study in 1975 was performed to evaluate the effect of introducing low-dose in-feed oxytetracycline as an AGP on the intestinal floras of chickens and farm dwellers (Levy et al., 1976). The results showed not only colonization of the chickens with tetracycline-resistant and other drug-resistant *Escherichia coli* strains but also the acquisition of resistance in *E. coli* in the intestinal flora of the farm family.

LIVESTOCK FARMING AND ANTIBIOTICS

Antimicrobials are delivered to animals for a variety of reasons, including disease treatment, prevention, control, and growth promotion/feed efficiency. The use of antibiotics in livestock farming as growth promoters is common practice to meet the increasing demand for animal protein (meat, milk, egg, etc.). Antibiotic growth promoters (AGPs) were first advocated in the mid-1950s when it was discovered that small, subtherapeutic quantities of antibiotics could enhance the feed-to-weight ratio for poultry, swine, and beef cattle (Stokestad and Jukes, 1950). A variety of antibiotics growth promoters are used in animal feeds to maximize the efficiency of production, product quality, and to control diseases (Vidanarachchi *et al*., 2005). AGPs have been used widely in livestock production for almost 50 years. Although the modes of action of AGPs are not fully understood, the main effects are thought to be mediated via the gut-associated bacteria (Gaskins *et al*., 2002).Antibiotic growth promoters (AGP) enhance production by limiting the growth of pathogenic microorganisms (Arowolo and He, 2018).

Effect on public health

It is a very well established concept that the use of antibiotics has positive effects on growth promotion. Besides this positive aspect of antibiotics, it is creating a very serious public health problem of antimicrobial resistance associated with livestock.There are many studies available that support the fact that antibiotic use in food animals raises antibiotic-resistant bacteria among the farm people and to the distant people through the food chain(Fey et al., 2000). The high volume of antibiotics in food-producing animals contributes to the development of antimicrobial-resistant bacteria, particularly in settings of intensive livestock farming. In some countries, the total amount of antibiotics used in animals is 4 times larger than the amount used in humans. In many countries much of the antibiotics used in animals are for growth promotion and prevention of disease, not to treat sick animals. European Union banned

the use of antibiotics as growth promoters in 2006, because of its harmful impact on public health.

These antibiotic-resistant bacteria can be transmitted from animals to humans eitherthrough direct contact, food (milk, meat, or egg)or the environment (contaminated fruits, vegetables, soil, water, etc.). Sometimes, infectious caused by these bacteria in humans can cause death because of the failure of all available antibiotics to treat that infection. Also, the use of antibiotics in food animals is one of the main reasons for the emergence of new fungal diseases. Increased cases of the compromised immune system are also one of the consequences of antibiotic use in food animals. WHO recommends an overall reduction in the use of antibiotics in food-producing animals to help preserve their effectiveness for human medicine.Currently, antimicrobial resistance associated annual death recorded as 0.7 million which may reach up to 10 million in 2050 and it is also estimated that loss to global economy may reach upto100 trillion dollars along with 3.5% reduction in the global gross domestic product (GDP) till 2050 (O'Neill, 2014). The use of antibiotics in food animals not only harm human but also the animals and the environment.

Alternative to antibiotics in animal production

According to a study,India accounts for 3% of global consumption of antibiotics in poultry, swine, and cattle in 2010 and is among the top consumers worldwide besides China, USA, Brazil, and Germany, and its consumption will increase by 82% in India by 2030. If this will continue, then it would make the situation worse.Sweden was the first country in Europe that banned the use of AGPs in 1986 followed by the European Union in 2006 because of the emergence of antibiotic-resistant bacteria. However, the ban on AGPs resulted in an increased incidence of enteric disorders in food animals. Some other countries are also trying to restrict and regulate the use of antibiotics as antibiotic growth promoters.Before the implementation of this complete ban on the use of AGPs, some experts attempted to assess possible effects on growth rate and feed conversion efficiency and discussed possible alternatives after the ban (Wenk, 2003). But, now the time has come to replace the use of AGPs in livestock farming gradually with natural growth promoters. So that menace of AMR associated with livestock can be tackled efficiently without affecting the growth and production efficiency of animals.This leads to increased demand to search for natural growth promoters which will as efficient as AGPs.The probiotics, prebiotics, and phytobiotics possess great potential to substitute AGPs.

The use of plants and plant bioactive compounds for treating various human and animal diseases is as old as human civilization (Li, 2000). It is well documented that ancient Egyptians, Chinese, Indians, and Greeks (Kamel, 2000) have used plants extensively for the treatment of various ailments related to humans and animals. In recent years, there has been an increased awareness of the potential that natural plant compounds have in the prevention and treatment. Term 'Phytobiotics' are used for the plant-derived bioactive compounds. Many studies claim that phytobiotics can enhance growth, production potential, the performance and well being of animals.The phytobiotics have

many beneficial properties like prebiotics, probiotics, antimicrobial, anti-inflammatory and prevent the binding of harmful bacteria to the intestinal mucosa. A few phytobioticswith their properties are described below-

- Thyme and yarrow extracts are reported to have the potential to reduce caecal counts of *Clostridium perfringens* when incorporated in the broiler diets (Cross *et al*., 2004).
- The plant extracts containing capsaicin (1.98 g/100g), carvacrol (4.95 g/100g) and cinnamic aldehyde (2.97 g/100g) reduced *C. perfringens* and *Escherichia coli* counts in colonic contents, which is comparable to birds treated with the antibiotic, avilamycin (Jamroz*et al*., 2003).
- Plants derived bioactive agents like thymol,carvacrol, phenylpropane, geraniol, etc. have antimicrobial properties (Yang *et al.,* 2015).
- The yeast cell wall contains phosphorylated mannan oligosaccharides (MOS) that prevent the binding of harmful bacteria to GIT mucosa (Spring *et al.,* 2000).
- Guo*et al*. (2003) found thatwhen two mushroom species; *Lentinusendodes*and *Tremellafuciformis*, and a herb, *Astragalusmembranaceus radix*, was fed to chickens, then activation of innate and adaptive immunity was observed.
- The phytobiotics containfructooligosaccharides residues which were claimed to leads to the upregulation of immunoglobulin A (IgA) secretion in murine Peyer's patch cells in the intestinal mucosa (Hosono*et al*., 2003).
- Essential oils extracted from various plants possess anti-inflammatory like chamomile essential oil has been used traditionally for centuries as a drug in eczema, dermatitis and other irritations (Kamatou and Viljoen, 2010). Essential oils from pine, clove, and myrrh have been used in mixed formulations as antiinflammatory agents (Darsham and Doreswamug, 2004).

CONCLUSION

Besides various achievements in the animal food production of milk, meat, eggs, etc., India still facingtremendous pressure to meet the increasing demand for animal protein. The use of antibiotics is a common practice in livestock farming to increase growth performance and production potential. And, its use will increase soon, besides its harmful effect on public health which will worsen the AMR menace.To tackle the problem of development AMR associated with livestock, phytobioticscan be used as an alternative to AGPs.Many studies suggest that phytobiotics may have the potential to increase the growth performance and productivity of the food animals in a similar way as AGPs. More research efforts should be carried out to develop and marketing the non-antibiotic animal growth promoter to maintain the sustainability of animal husbandry and to meet the ever-increasing demand of animal proteins.

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Major cultivation problems of pointed gourd (*Trichosanthes dioica Roxb.*) and their respective efficient management strategies at Indian context

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The pointed gourd (*Trichosanthes dioica* Roxb.), popularly known as 'parwal' or 'patal' is one of the mostly cultivated cucurbit in the country having year round market demand thus fetches a lucrative return. It is a highly nutritious wholesome vegetable, regarded as 'King of gourd' due to immense nutritional qualities like higher protein content, vitamin A (153 mg/100 g) and minerals. It is easily digestible, diuretic, and laxative, invigorates the heart and brain and is useful in the disorder of the circulatory system (Malek, 2009). Seeds of *T. dioica* have been reported to possess antibacterial as well as antifungal activities. Pointed gourd has total 18 million ha area with a production of 268 mt. It is grown extensively in river beds or basins called 'Diara' in the states of Bihar (27%), U.P., West Bengal and Assam in India. Traditionally the crop is either grown in soil bed or trained on bower/trellis system. The plant is a perennial, dioecious, and grows as a vine, usually propagated through vine cuttings and root suckers (Hassan et al., 2020). Seeds are not used in planting because of poor germination and inability to determine the sex of plants before flowering. As a result, crop established from seed may contain 50% non-fruiting male plants. Both pre-rooted and fresh vine cuttings are used for propagation. Since this vegetable is grown during hot humid climate, it suffers from several disease and pest infestation in different parts of India (Kumar and Singh, 2012). Thus, from above information we can easily considered pointed gourd as one of the major profitable vegetable in our country that faces so many problems during its cultivation. In this article, we try to work out efficient management strategies for the identified major cultivation problem in pointed gourd.

Cultivation problems and management strategies:

1. *Problem related to age old vine cutting propagation technique*

Only 8-10 cuttings produced from each plant in 1 year by the conventional method of vegetative production. The practice demands a large quantity of material for planting. But present days, micro-propagation using shoot tip & nodal segments about 8 shoots can be obtained from a single explant in 4 weeks. Therefore micro-propagation has the potential for producing large number of quality propagules of elite clones in short period. In India, the Agro Division of Cadila Pharmaceuticals limited is producing 0.3 million plants per annum of Anawal pointed gourd through tissue culture at a price of Rs.12/- each in Gujarat state.

2. Dioecious sex expression and pollination problem

As because of dioecious nature of the crop, male-female ratio is very important. Through seed propagation male-female ratio is quite high. Due to this about more than 50% of the plant produce staminate flower and remains unproductive. Therefore it produces less yield and thus reduces the productivity of the crop. Beside this, drying of flowers 1–2 days after anthesis, or yellowing and drying of fruit 5–7 days after anthesis is a common problem during summer. This has been attributed to the lack of pollination and subsequent ovule fertilization during summer months. Both problems underscore the importance of maintaining a ratio of 1 staminate to 10 pistillate plants. Pollination through pollen grains suspended in water and hand pollination resulted in 12.90 and 9.36% increase in fruit setting, respectively. Foliar application of gibberellic acid (GA_3) at 40 mg/litre of water increased the number of pistillate flowers by 23% and decreased flower abortion by 20%, resulting in increased fruit set by 18.7% (Bharathi et al., 2013). Application of silver nitrate @ 1000 ppm also successfully induces hermaphrodite flower and parthenocarpy in pointed gourd.

3. *Lack of high yielding germplasms in cultivation*

Still there is lacking of effort to popularize the F1 hybrids and zone specific improved variety that makes obstacle to reach high yield and higher productivity in our country. Farmer's usually collect vines of locally available cultivars and use it for cultivation. For improving productivity farmers may adopt the cultivars from following table according to suggestion from scientist:

Cultivar/Variety	Salient features
Kashi Suphal (IC-599391)	Identified and release by CVRC for U.P. in 2018 having attractive light green fruit colour with mild stripe and slightly tapper at the stem end and blossom end. Variety can withstand upto 40^{o}C and yield potential is 190-200 q/ha, suitable for culinary, stuffing and confectionary purpose
Kashi Amulya (IC-620681)	Identified and release by CVRC for U.P. in 2018 having less number seeds of 5-8 /fruit as compare to 20-28 seeds in seeded variety that makes the fruit more feshy and can be harvested for longer duration
Kashi Alankar	High yielding, recommended for U.P., Bihar, Jharkhand

Rajendra Parwal -1	Long, green fruit with white stripes, tapering at both ends; 40 g, suitable for long-distance transport; tolerant to fruit fly; suitable for cultivation in both riverbed and upland areas
Rajendra Parwal - 2	Drum-shaped, whitish green fruit with very light stripes and soft mesocarp; 30 g; tolerant to vine and fruit rot as well as fruit fly; suitable for cultivation in both riverbed and upland areas
Swarna Rekha	Fruits elongated (8–10cm long), tapering at both ends, striped, with soft pulp, recommended for cultivation in Jharkhand, Bihar, Orissa, West Bengal, and eastern Uttar Pradesh states of India
Swarna Alaukik	Fruits 5–8cm long, light greenish with blunt ends, suitable for sweet preparation; recommended for cultivation in Jharkhand, Bihar, Orissa, West Bengal and eastern Uttar Pradesh states of India
Swarna Suruchi	Developed through clonal selection, Fruit elongated in shape, light greenish in colour, suitable for table and sweet preparation.
CHES Hybrid - 1	Large-sized, dark green-striped attractive fruit. First pointed gourd hybrid developed; firm fruits, firm, green, striped, each 30–35 g; highly tolerant to fruit fly infestation
CHES Hybrid - 2	Dark-green, striped fruits, 25–3
Faizabad Parwal- 1	Attractive, round, green fruits; commercially cultivated in Uttar Pradesh and adjoining areas of Bihar
Faizabad Parwal -3	Spindle shaped, green fruit with few stripes; excellent culinary properties; suitable for cultivation in eastern and western Uttar Pradesh
Faizabad Parwal- 4	Light-green fruit, spindle shaped with tapering ends; recommended for bower/pole system of cultivation and for reclaimed sodic soils
CHPG-15	The genotype has dark green colour with 3-4 fragmented stripes of cream colour, which has high market preference. With better management practices, 50-60 tonnes/ha fruit yield (2500 plants/ha) can be obtained from CHPG-15 under upland conditions
Dandali	Medium-size fruit (6.8-3.9 cm), egg shaped, light green, stock end dispersed, striped slightly and grooved toward distal end.

4*. Problem due to biotic stress*

Within insect-pests, fruit fly (*Bactrocera cucurbitae*) followed by red pumpkin beetle (*Raphidopalpa foveicollis*) causes major damage to the fruit. Since, pointed gourd is traditionally cultivated on flat soil based system; it is highly susceptible to attack of several soil-borne pathogens like *Phytophthora melonis* (previously referred as *P. cinnamomi*) that causes fruit and vine rot which is considered as major fungal disease. Besides this, downy mildew (*Pseudoperonospora cubensis*) and root-knot nematode

(*Meloidogyne incognita*) also affect the yield of fruit to great extent. Recently, a fungal disease namely, net blight causing 43% disease infection was reported from Central Horticulture Experimental Station, Bhubaneswar where *Scelerotium spp*. tentatively identified as causal organism. Severity of scelorotinia rot caused by same fungal pathogen (earliar *Sclerotinia sclerotiorum*) was already reported from West Bengal that infects the nodal region of vines causing wilting and drying followed mycelial growth on fruits resulting in rotting of the fruits (Khatua et al., 2014). Details of symptom and management strategies of major disease and pests are given in following table.

Table 1: Important disease and pest identified in pointed gourd and their effective remedial measures

Disease (Causal organism)	Symptom	Management strategies
Fruit and vine rot (*Phytophthora melonis*)	Locally known as 'Haza', earlier it is characterized by drying of vines and fruits followed by water soaked lesion, discolouration, and mycelial growth on fruit surface that causes shrinkage of fruit at later stage	Soil drenching with captan or cabendazim (0.2%) at 10-15 days interval, use raised bed or better to use trellis system to avoid contact of soil with fruits. Five times application of Propineb (Antracol), Fosetyl-Al (Aliette) and Fenamidone (10%)-Mancozeb (50%) (Sectin)/ Metalaxyl + Mancozeb (0.2%) in alternative ways at fifteen days interval starting from the initiation of the disease
Downy mildew (*Pseudoperonospora cubensis*)	Initially, pale green spots on upper surface followed by chlorosis and necrosis in severe cases and purple spots on the lower surface of leaves	Spraying of Krilaxyl Gold (Metalaxyl 8% WP + Mancozeb 64% WP), Blitox (Copper Oxy-chloride 50% WP) and Indofil M-45 (Mancozeb 75% WP) just before sunset
Root-knot nematode (*Meloidogyne incognita*)	Formation of root gall that causes reduction in root and shoots growth thus made the affected plants become stunted and may die in severe case.	Follow vine dipping with monocrotophos 36SL (1000 ppm) followed by soil ino-culation of *Trichoderma viride* @ 10g per pit once at planting and 2nd after 40 days of planting. Furadan 5G + poultry liter is effective in suppressing or reducing root knot nematode.
Pest	**Symptom**	**Management strategies**
Fruit fly (*Bactrocera cucurbitae* Coq.)	It lays egg 2-4 mm deep in the fruit and maggot feeds inside the fruit. Fruits become	Use cue-lure trap @25-30 traps per ha prior to flower initiation. for attracting male flies, bagging of

	distorted and drops from the plant	fruits or spray insecticides like Chlorfenapyr 10% SC @ 50 g a.i./ha
Red pumpkin beetle *(Aulacophora fovicollis)*	Cuts leaf lamina causing irregular holes or complete defoliation and severe damage occurs specifically at cotyledonary stage	Ploughing of soil, traditional application of dry ash, powdered black soil, red chilli powder beside use of muskmemelon as alternate host and spraying of chemicals like spinosad 45 SC @ 1 ml/litre of water are some of the most effective control measure of red pumpkin beetle.

CONCLUSION

We have critically reviewed the production problems of pointed gourd observed all over the country along with their effective measures worked out in different research station and from research trial conducted by different institute and also from ITKs (Indigenous Technological Knowledge) practiced by the farmers. Thus finally we may conclude if the farmers followed control measures mentioned in this article to protect pointed gourd against the problems faced in field, definitely get increased their yield and thereby generate lucrative return.

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Recent advances in disease diagnosis for sustainable livestock and poultry production

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The livestock play a very important economic and socio-cultural roles for the wellbeing of rural households, such as food supply, source of income, asset saving, source of employment, soil fertility, livelihoods, transport, agricultural traction, agricultural diversification and sustainable agricultural production since the time of ancient civilization and domestication of animals. Livestock production is predominantly familiar being chickens, pigs, goats, cattle, horses, buffaloes and sheep the main species. Beyond the economic function, each livestock species also performs social and cultural functions.

Sustainable livestock production means making livestock systems economically more efficient and striking balance between meeting the growing demand of animal origin products and reducing to the minimum the negative side effects and externalities from the livestock sector. In order to be optimal, livestock systems need to promote advancements in the technological and infrastructural aspects of the sector and, at the same time, institutions and experts should support the progression of knowledge with policies that define and shape sustainable livestock development from a social, economic and environmental perspective.

A number of factors may adversely affect the stability and health of animal populations. Environmental stresses, poor nutrition and infectious agents play serious constraints on animal productivity, especially in the developing world, resulting in several disease condition and heavy economic losses. Infectious diseases, in specific, threaten the health and well being of wildlife, livestock, and human populations. The actual impact of any given infectious disease depends on morbidity and mortality patterns, susceptible host range and subsequent losses like death, loss of productivity, infertility etc. In addition infectious diseases of animal population carry global public health risks of sporadic human zoonotic infections or emergence of a pandemic strain. As a whole, animals are thought to be the source of more than 70% of all emerging infections (1).

SIGNIFICANCE AND CHALLENGES OF DISEASE DIAGNOSIS

Prompt and accurate detection of infectious agents is necessary, since many livestock diseases have severe economic consequences, yet local veterinary diagnosis can be confounded by diseases that share similar clinical signs. Therefore, the presence of notifiable diseases is usually confirmed in dedicated laboratories, using assays recommended by the World Organization for Animal Health (OIE). These tests are typically performed, analyzed and interpreted by trained personnel, according to the recommendations of the OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals (Terrestrial Manual) (2). Although these laboratory-based tests can provide rapid results (3), samples must be transported to the laboratory, which can negatively affect the quality of the specimens and delay or even hinder immediate crucial decision-making and the process of disease control.

The pathogen detection is an important step for the accurate diagnostics, successful treatment of animal infection and control management in farms and field conditions. Serious efforts are focused on the early detection of the causative agents, considering that the timely recognition would prevent their spread to large animal populations in huge geographic areas. Thus, the development of novel, powerful diagnostic assays is a basic issue today in veterinary research and animal health care.

Current techniques employed to diagnose bacterial pathogens in livestock and poultry include classical plate based methods and conventional serological methods as enzyme linked immunosorbent assays (ELISA). Isolation and propagation of virus is an effective method for diagnosis but it is time consuming. Although, molecular techniques such as polymerase chain reaction (PCR) and real time PCR (RT-PCR) have also been proposed to be used to diagnose and identify relevant infectious disease in animals, these DNA-based methodologies need isolated genetic materials and sophisticated instruments, being not suitable for field use. Consequently, there is strong interest for developing new swift point-of-care biosensing systems for early detection of animal diseases with high sensitivity and specificity (4).

Advances in Veterinary disease diagnosis

The development of simple, portable diagnostic devices is now considered a priority for animal diseases. The global veterinary diagnostics market is estimated to expand at a compound annual growth rate of 8.6% from 2016 to 2021, to reach US$ 6.71 billion by 2021 (4). Molecular biology offers a range of new methods, which are able to accelerate and improve the diagnosis of infectious diseases in animals and man. The new assays provide possibilities for rapid diagnosis, since the detection of pathogen can be completed within hours. Concerning direct detection, various molecular approaches are introduced, like classical PCR robotics, portable PCR machines, improved sample enrichment, amplification without thermo cycling, macro and microarrays are under development.

i) Nucleic acid hybridization and real-time polymerase chain reaction (qPCR) assays have been applied for routine diagnosis of a large number of diseases. Real-time PCR chemistry (qPCR) is now an established tool to detect and quantify nucleic acid in

laboratory settings, offering superior analytical sensitivity for the detection of acute disease, in comparison to serologically based assays. As a result of this routine laboratory use, much progress has been made recently in transitioning qPCR. The real-time PCR allows estimation and quantification of pathogen load. Such estimation opens new paths not only for the diagnosis, but also for studying pathogenesis. The measurement of viral load is also important when estimating the effects of anti-viral treatments, especially in animal virology.

ii) Diagnostic serology: Antibodies have the capacity to actually bind to antigens which are unique to specific microorganisms. Because antibodies are only produced after an encounter with a foreign antigen, the presence of specific antibodies is indicative of exposure to, if not infection with, a certain micro-organism. Such a detection of specific antibodies in blood and other body fluids forms the basis of diagnostic serology. Serological techniques have been used for well over half a century for the presumptive diagnosis of infectious diseases.

iii) Microarrays: Microarray refer to the collection of microscopic spots containing picomoles (10-12 moles) of a specific sequences (DNA, cDNA, cRNA, oligonucleotides), known as probes, which hybridize with specific nucleic acid sequence called targets, labelled with a fluorescent dye. Use of microarrays during outbreaks and and/or disease surveillance would save time and help in early decisions to control the spread of disease. One main pathogenesis in terms of gene expression studies during host pathogen interactions.

iv) Genotyping by Pyrosequencing: This is a real-time de novo DNA sequencing method catalyzed by the cascading actions of four kinetically balanced enzymes: i) DNA polymerase ii) ATP sulfurylase iii) firefly luciferase and iv) apyrase. The phylogenetic analysis by sequencing the 16srRNA gene or the advent of new microbial identification easier along with culture-independent studies (or metagenomics) for exploration of all microbial genomes. Pyrosequencing based diagnostic assays were developed for the detection of H5N1 viruses that are capable of rapidly determining an isolate's clade, strain, receptor specificity, glycosylation status and HA0 cleavage site (5). As more is learned about the molecular basis for influenza virulence, pyrosequencing based assays may be developed subsequently, to rapidly screen for virus isolates that may pose a greater risk to animal and human populations.

v) Biosensors: These are attractive solutions for fast and efficient infectious disease diagnostics due to their simplicity, possible miniaturization and potential ability for real-time analysis. Biosensor recognizes a target biomarker, characteristic for particular pathogen, via an immobilized sensing element called bioreceptor (monoclonal antibody, RNA, DNA, glycan, lectin, enzyme, tissue and whole cell). The bioreceptor is a crucial component as its biochemical properties assure high sensitivity and selectivity of the biomarker detection and permit to avoid interference from other microorganisms or molecules present in the tested sample. Biosensor methods has been widely used for the detection of various animal and poultry pathogens, by targeting various pathogen associated biomolecules like cell wall components, pathogen specific proteins/toxins, extracellular components like flagella etc.

CONCLUSIONS

In conclusion, the early identification of infectious diseases in domestic and wild animals is crucial to improve control program. A major thrust in the development of animal disease diagnostics has been toward rapid methods that can provide a definite answer in the earliest possible time period. To achieve such rapidity, the methods should fulfill the prerequisites of speed, simplicity, sensitivity, specificity, reproducibility and low cost. More rapid advances in biotechnology, such as nucleic acid probe techniques, will no doubt allow for rapid and economical identification in the future, but at present they are still considered as experimental techniques, will no doubt allow for rapid and economical identification in the future. Such a rapid, powerful and internationally standardized molecular diagnosis contributes to the reduction of losses caused by the pandemic/transboundary diseases among animal populations.

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Nepeta longibracteata : Blue flower in cushion of cotton

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Nepeta is one of the largest genus of flowering plants belonging to Lamiaceae or mint family. The genus name is reportedly in reference to Nepeta, an ancient Etruscan city. There are about 300 species, most of which are perennial and herbaceous. The members of this group are known as catnips or catmints, because nepeta pleasantly stimulates cats' pheromonic receptors. Its distribution is abundant in Europe, central Asia, North America, Japan, China, Korea, Canary Islands and Africa.South-western Asia regions especially in Iran where the genus represents more than 12 species. *Nepeta longibracteata* or long-bract catmint is found in temperate and alpine regions of Himalayas. Vernacular name of this plant in Ladakhi is 'Prianku'. Long-Bract Catmint is a clump-forming, lemon-scented perennial herb with a creeping rootstock. It is very common in Lahaul-Spiti (Himachal Pradesh) at above 3500m altitudes.

HABITAT:

Nepeta longibracteata thrives well on stony slopes and dry gravel barren land. Due to its habitat specificity, the plant is categorised as drought tolerant and shows water conserving properties. Long-Bract Catmint is found in the Himalayas, from Pakistan to Himachal Pradesh, on screes and stony slopes at 4400-4800 m altitudes. *Nepeta longibracteata* is prominent in areas of North-East Afghanistan, Pamir-Alai, Pakistan, Kashmir, Lahul, Tibet and Sinkiang.

VEGETATIVE CHARACTISTICS:

Nepeta longibracteata Benth., syn *Glechoma longibracteata* (Benth.) O. Kuntze is a perennial herb attains 8-15 cm height. It is aromatic in nature and exhibits small cotton like cushions for reproductive structure. Multiple stem, purplish with a vinous indumentum to glandular pilose. Leaves are small and ovate present below the inflorescence, ovate and having coarsely crenate margins.

In it, bracts are longer than flowers, which are densely ciliated and purplish in colour. Leaves are cauline as well as scale-like type. These are ovate-rhombic or inverted lanceolate about 6 -10 mm, narrower wedge shaped base and having deeply incised with obtuse rounded lobes, grey wooly, boldly toothed tip, villose to pilose; flattened petiole. The perennial plant show creeping nature. The aromatic culinary herb having several stems arranged in ascending and prostrate manner, that is 7-12 cm long.

Floral biology

Flowers are tubular similar to lavender and enriched with small purple dots. Inflorescence is ovoid congested located in verticillasters group or racemes, opposite cymes or at terminal in position, subtended by tiny uppermost leaves. Bracts are violet to dark purple; longer than flowers provides a unique identity to the species. Calyx is campanulate or tubular, long, curved or slightly linear, white villose, thin textured, 5-8mm, unequal teeth with five teeth and often two lipped. Corolla is white 12-18mm long, blue or purplish with deeply bind upper lip, whereas lower lip is slightly broader at middle. Stamens are longer and lack hairy outgrowth on surface. Fruits are ovoid or oblong in shape and mainly smooth, ribbed nutlets type. Flowering occurs in month of mid -July to August.

Propagation:

Almost all parts of plants are aromatic in nature. The cultivation of *Nepeta longibracteata* are not well known, since they mainly propagated by stem cutting methods. Due to its aroma qualities, foliages grown for their edible and decorative purpose at native habitats of temperate regions. It is also known as catmint or Long-Bract catnip, forming less clump. The herb is spotted with dark purple oftenly lanceolate bracts borne on cotton like ovoid cushion head. Because of nepetalactone compound, it

causes adverse effect on olfactory receptors of house cats, leads to temporary euphoria disease in cats.

Medicinal uses:

Catmint has long historical background and glorious tradition as herbal remedy. The global trend shows there vival in interest for traditional medicinal system**.** It is considered as important herb by amchis of Lahaul-Spiti. The formulation of herbal medicine that intake indigenously having very minute quantity of this herb. The plant used for the ailment of multiple diseases and shows pharmacological responses effect as sedative, carminative, febrifuge, anti-asthmatic, antioxidant, diaphoretic, cholesterol lowering, anti-inflammatory, relaxant, vermifuge, antimicrobial, and diuretic properties. Beside these its specific chemical composition shows the insecticidal and herbicidal. This very distinctive high altitude scree plant used as a universal cure herb by Lahoulis in northwest Himalayas. According to ladakhis people the roots of this plant is harmful for the peoples suffered from stomach and liver disorders. The whole plant of *N. longibracteata* is also used as a flavouring agent. The catmint is effective for induce sleeping in patients suffers from insomnia.

Chemical constituents:

According to the phytochemistry, chemotypic essential oils are present in all plant parts. The first is the nepetolactone and 1,8-cineole and/or linalool represented in the whole Nepeta genus. These chemicals provide platform for the ailment of diseases related to depression, inflammation, diabetes, high lipid and cardio protective drugs. Recent discovery shows that *n*-hexane fraction of *Nepeta longibracteata* (NlH) exhibited most significant antibacterial activity against *E. coli* and *S. aureus* comparable to that of clove oil. Oil isolated from catnips by steam distillation is a repellent against insects, in particular mosquitoes, cockroaches and termites. Due to these positive effects, the urge for extensive research and clinical trials in various diseases treatment is necessary.

Agriculture aspect:

It also have repellent or insecticidal properties to wide range of pests such as bugs and aphids. Extracted oil is also act as good repellent that can be used against termites, mosquitoes and insects as well.

CONCLUSION AND FUTURE PROSPECTIVE:

Floriculture got a substantial gains in characterization of wild germplasm and develop potential hybrids of community research. The introduction of new germplasm open the research gate of floricuturist in the direction of domestication conservation and upcoming thrust areas in floriculture. It contributes fruitful avenue to generate employement in urban and rural areas. Recommended future directives for conduct of research trials are pointed out to validate the importance of such plant species. There is urgent need to keep these plant species in the pipe line of conservation and domestication with deep interest by using modern techniques of floriculture.

Figure1. Specimens of Nepeta longibracteata collected at Suraj tall at 4890m (Himachal Pradesh) in 2018

Major Diseases of Rice and its Management

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Rice Blast:*Magnaporthe oryzae* (**anamorph:** *Pyricularia oryzae*)

Symptoms

Rice blast caused by a fungus, causes lesions to form on leaves, stems,Collar, Neck, Node peduncles, panicles, seeds, and even roots.

Period of occurrence: All stages of crop (seedling to maturity)

Rice leaves

Symptoms may vary according to the environmental conditions, the age of the plant, and the levels of resistance of the host cultivars on susceptible cultivars, lesions may initially appear gray-green and water-soaked with a darker green border and they expand rapidly to several centimeters in length. In the leaf blast, the lesions on leaf blade are usually elliptical or spindle shaped with brown borders and gray centers. under favorable conditions, lesions enlarge and coalesce eventually killing the leaves.

Rice Collars

The collar of a rice plant refers to the junction of the leaf and the stem sheath. Symptoms of infection of the collars consist of a general area of necrosis at the union of the two tissues .Collar infections can kill the entire leaf and may extend a few millimeters into and around the sheath. The fungus may produce spores on these lesions.

Nodal Blast

The pathogen also infects the node of the stem that turns blackish and breaks easily; this condition is called node blast.

Rice necks and panicles.

The neck of the rice plant refers to that portion of the stem that rises above the leaves and supports the seed head or panicle. Neck of the panicle can also be infected. Infected neck is girdled by a grayish brown lesion that makes panicle fall over when infection is

severe. The pathogen also causes brown lesions on the branches of panicles and on the spikelets. Infection of the necks can be very destructive, causing failure of the seeds to fill (a condition called blanking) or causing the entire panicle to fall over as if rotted. The rice blast fungus can also infect the panicles as the seeds form. Lesions can be found on the panicle branches, spikes, and spikelets. The lesions are often gray brown discolorations of the branches of the panicle, and, over time, the branches may break at the lesion

Rice seeds.

The fungus has often been isolated from the pedicels of the seeds. Seeds are not produced when pedicels become infected, a condition called blanking. Symptoms of rice blast on seeds themselves consist of brown spots, blotches and occasionally the classic diamond-shaped lesion often seen on leaves. The process and the time during which infection of seeds by spores of the pathogen occurs has not been fully described but recent information shows that the fungus can infect seeds by infecting the florets as they mature into seeds, and it is believed that this is the main way seed infection develops.

Management

Use of resistant varieties like Gauthami, IR-36, IR-64, Parijatha, Rasi, Sasyashree, Salivahana, Simhapuri, Srinivas, Tikkana.

- Crop rotation is one simple and effective technique that is highly recommended simply because it provides a mechanism that separates viable spores in crop residue from the newly emerging seedlings.
- Over use of nitrogen fertilizers, as increases the amount of rice blast .
- A technique that is often overlooked or difficult to employ in some fields is maintaining a proper flood level for the rice to grow. Finally, using high quality and disease-free seed is always highly recommended because infested seeds left on the soil surface provide inoculum from which epidemics develop
- Seed treatment with *Pseudomonas fluorescence* 10g / 1 Liter of water for 30 min.
- Seedling root dip treatment with *Pseudomonas fluorescence* (4g / 1 Liter of water) for 20 min.
- Foliar spray of *Pseudomonas fluorescence* (4g / 1 of water) at 20-25 days after transplanting.

Chemical Management

Spraying of chemicals like Tebuconazole + trifloxystrobin 75 % (WG) @ 65 gm/acre or azoxystrobin + difenoconazole 29.6 % (SC) 200 ml/acre, Difenconazole+Propiconazole 125 ml/Acre controls the blast.

Brown Spot: *Bipolaris oryzae, Cochilobolus miyabeans* **(synonyms:** *Dreschlera oryzae***,** *Helminthosporium oryzae***)**

Occurrence: At all crop stages, but the infection is most critical during maximum tillering up to the ripening stages of the crop.seedling to milk stage.

Symptoms

In seedlings the fungus produces small, circular brown lesions which may girdle the coleoptile and cause distortion of the leaves. In older plants, the lesions on the leaves are light brown to gray in the center and have a reddish brown margin. Lesions vary between 1-14mm long.On glumes, black or dark brown spots are produced resulting in discoloured and shrivelled grains. The fungus may penetrate the glumes and leave blackish spots on the endosperm. Severe infection of grains has been reported to prevent germination and to cause seed rotting and pre-emergence damping off. Young roots may also show blackish lesions. Nodes and internodes are rarely infected. The pathogen has also been reported to cause brown to dark brown lesions (5-15 x 1-2 mm) on panicle stalk at the joint of flag leaf to stalk.

Management

- Provide balanced Nutrition to crop.
- Use of resistant cultivar.
- Use of disease free seeds.crop rotation.
- Clean of rice ebrid and Weeds.
- Since the fungus is seed transmitted, a hot water seed treatment (53-54°C) for 10-12 minutes may also be effective before sowing. Seed treatment with fungicides like Mancozeb
- Spraying of chemicals like Azoxytrobin+Difenconazonle @ 200 ml/acre, Tebuconazole+Trifloxystrobin @65 gm/acre

Sheath blight: ***Rhizoctonia solani*** Kühn (**Teleomorph:** *Thanatephorus cucumeris* (A. B. Frank) Donk.)

Occurrence: Tillering to milk stage

Symptoms

Early symptoms usually develop on the leaf sheaths at or just above the water line. oval or ellipsoidal greenish gray lesions, usually 1-3 cm long appears on the leaf sheath under favorable conditions, these initial lesions multiply and expand to the upper part of the sheaths, the leaves, and then spread to neighboring tillers belonging to different hills (transplanted rice) or plants (direct-seeded rice). As the disease progresses, they enlarge and tend to coalesce forming Irregular larger lesions with grayish white centers surrounded by tan to dark brown irregular borders or outlines. Infection can spread to leaf blades and cause irregular lesions with dark green, brown, or yellow-orange margins. As the plant approaches heading. The disease may move up the plant and infect the flag leaves and panicles under severe conditions.Plants heavily infected in the early heading and grain filling growth stages produce poorly filled grain, especially in the lower part of the panicle.

Management

- Use Resistant Varieties.
- Avoid excess 'N', skip final 'N' in sheath blight infected fields.
- Field Sanitation, Crop rotation and Avoid dense canopy.

- Soil application of *P.fluorescens* @ of 2.5 kg/ha after 30 days of transplanting (product should be mixed with 50 kg of FYM/Sand and applied).
- Foliar spray *P.fluorescens* at 0.2% at boot leaf stage and 10 days later
- Spraying fungicides of 1g carbendazim 50WP (540g/acre) or 2.0g mancozeb 75WP OR 1ml hexaconozole in liter of water.
- Spraying of fungicides like Azoxystrobin 18.2% + difenoconazole 11.4% SC @1.25ml/L or hexaconazole 5% EC @ 2.0 ml/l or azoxystrobin 23% SC @ 1.0 ml/l .

Sheath Rot: *Acrocylindrium oryzae* Sawada**,*Sarocladium attenuatum* W. Gams & D. Hawksw.**

Occurrence: Heading to maturity stage

Symptoms

Rot occurs on the uppermost leaf sheaths enclosing the young panicles. the lesions start as oblong or somewhat irregular spots, 0.5–1.5 cm long, with brown margins and gray centers or they may be grayish brown throughout; they enlarge and often coalesce and may cover most of the leaf sheath; the young panicles remain within the sheath or only partially emerge; an abundant whitish powdery growth may be found inside affected sheaths and young panicles are rotted. *S. oryzae* infection results in chaffy, discolored grains, and affects the viability and nutritional value of seeds.

Management

- Removal of infected stubbles after harvest,control of weeds.
- Application of Potash at Tillering stage.
- Seed treatment with *P.fluorescens* @ of 10/g kg/ha of seed followed by seedling dip @ 2.5kg or dissolved in 100 litres and dipping for 30 minutes.
- Soil application of *P.fluorescens* @ of 2.5 kg/ha after 30 days of transplanting.
- Foliar spray at 0.2% concentration *Pseudomonas fluorescens* commencing from 45 days after transplanting at 10 days interval for 3 times depending upon the intensity of disease.
- Two foliar sprays of hexaconazole 5% + captan 70% WP @0.05% orhexaconazole 5% EC @0.20% were found significantly most effective in reducing the sheath rot intensity.

False smut of rice: *Ustilaginoideavirens*

Period of occurrence: Panicle emergence.

Symptoms:

The disease affects the grains and the symptoms produced are visible only after flowering. U. virens infects the young ovary of individual spikelets and converts them into large velvety green smut balls. Infected rice during the flowering stage inhibited flower fertility and development of adjacent spikelets. The lower part of spikes is generally more severely infected than upper part. Smut balls are initially yellow in

colour and are covered by a membrane, later the membrane bursts and the colour changes to yellowish green and finally greenish black.

Management

- Use diseases free seeds, Hot water treatment of seeds at 52 ^{o}c/1o minutes.
- Removal and destruction of diseased panicles in field.
- Two sprays were given for each treatment at booting stage 80 days after transplanting (DAT) and post flowering (100 DAT). Azoxystrobin 18.2 % + Difenconazole 11.4 % SC @1ml/L or Metiram 55 % + Pyraclostrobin 5% WG @1ml/L or Propiconazole 25 % EC @ 1ml/L

Bacterial Leaf Blight:*Xanthomonas oryzae* pv. *oryzae*

Occurrence: Tillering to heading stage

Symptoms

Kresek Phase: This phase is observed1-3 weeks after transplanting, This phase symptoms are confuses with early stem borer. It is distinguished from stem borer damage is by squeezeing the lower end of infected seedlings between the fingers show yellowish bacterial ooze coming out of the cut ends and other difference is that rice plants with kresek are not easily pulled out from soil as that of stem borer affected plants.On seedlings, infected leaves turn grayish green and roll up. As the disease progresses, the leaves turn yellow to straw-colored and wilt, leading whole seedlings to dry up and die.On older plants, lesions usually appears as water-soaked to yellow-orange stripes on leaf blades or Leaves with undulated yellowish white or golden yellow marginal necrosis, drying of leaves back from tip and curling, leaving mid rib intact Water-soaked to yellowish stripes on leaf blades or starting at leaf tips with a wavy margin

Management

- Grow tolerant varieties like IR20, IR72.
- Use disease free seeds avoid excess dosage of N fertilizer and N fertilizer should be applied in spilt be applied in split doses.
- Avoid clipping of seedlings during transplanting .Avoid flow of water from affected fields.
- Spray Streptomycinsulphate +Tetracycline combination 300g +copper oxychloride 1.25kg/ha.If necessary repeat 15 days later.foliar spray with copper fungicides alternatively with streptocyclin 250ppm to check secondary spread.

Rice Tungro disease: Rice tungro spherical virus (RTSV) and Rice tungro bacilliform virus (RTBV)

Occurrence: All stages of crop growth, starting from nursery

Symptoms

Yellowing of leaf tips, which then develop into yellow to orange discolouration of the leaves. In young plants, There is reduced tillers and incomplete root development occurs. Leaves may also become mottled, or have light-green to white stripes parallel to the leaf veins. shortening of the leaf blade and leaf sheath result in the stunting of the

plant. Flower development takes longer, which delays maturity and the panicles do not develop or exsert properly. Fewer grains are produced, and those that are yielded have a reduced weight and may be coated in brown blotche.

Vectors

The principal vector is *Nephotettix virescens*, other green leaf hoppers, *N. nigropictus*, *N. parvus*, *N. malayanus* and Reciliadorsalis also transmit the virus, but at a lower rate.

Management

- Use of Resistant varieties like IR 36, IR 50
- Destruction of stubbels and weed hosts
- In nursery when virus infection is low, apply Carbofuran granules @ 1 kg/ha to control vector population
- During pre-tillering to mid-tillering when one affected hill/m is observed start application of Carbofuran granules @ 3.5kg/ha to control insect vector
- Spray two rounds with Thiamethoxam 25 WDG 100g/ha or Imidacloprid 17.8 SL 100ml/ha at 15 and 30 days after transplanting.

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Diseases Management of Chilli Crop

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Damping off : *Pythium aphanidermatum* (Edson) Fitz.

Occurrence: In Nursery

Symptoms

The main characteristic symptom of the disease is pre emergence damping-off i.e., rotting of the seeds and seedlings before actual emergence from the soil and post-emergence damping-off which is severe when the seedlings are in cotyledonous stage.Water soaked lesion formed at collar region. The infected tissues become soft, brown and rot resulting in toppling over of the entire plant on the soil surface.

Management

- The cultural practices such as cover cropping and green manure incorporation, use of composts, crop rotation, and tillage practices improve soil compaction, increase drainage, and increase soil temperature.Soil solarization has been used for managing diseases caused by Pythium species. Soil solarization is a hydrothermal process that occurs in moist soil when the soil is covered by plastic film and heated by exposure to sunlight during the warm months. Bordeaux mixture 0.4% @ (40 gm of copper sulphate +40 gm of lime in 10 litres of water) or Copper oxychloride @ 0.2% (20 gm in 10 litres of water) is to be applied with rose can to a bed of 10 sq.m area 2 weeks after sowing.Two to three spray drenchings of beds with 0.2% Metalaxyl comencing three weeks after seed sowing (20 g of Metalaxyl in 10 l of water).

Fruit Rot and Die back: *Colletotrichum capsici*

Period of occurrence: Nursery, different stages

Symptoms

(i) In Nursery there will be occurrence of Seedling blight. (ii) At different stages of plant growth;The infection starts from growing tips (necrosis of apical branch, dieback)gradually advances downwards and infects the entire plant followed by leaves

and branches and then fruits.On the leaves, initially small-circular spots appear and the severely infected leaves fall off leading to defoliation of plant(iii) Fruit rot, where mostly ripe fruits are infected. Among the plant parts, most susceptible stage is ripe fruit stage. It causes extensive pre- and post-harvest damage to chilli fruits through disease lesions which reduce the market value of chilli fruits. Typical fruit rot symptoms include, as sunken necrotic lesions with concentric rings which produce conidial masses in pink to orange colour. Under severe conditions, lesions fuse and conidial masses may form concentric rings on lesions .black water soaked circular or angular sunken lesions, with concentric rings of acervuli that produce pink to orange conidial masses. Under severe disease conditions, more than one lesion may combine to form bigger lesions.

Management

- Deep ploughing, use of disase free seeds, Use of resistant varieties, Crop rotation.
- Treat the chilli seeds with *T. viridae* which gives higher seed germination
- Seed treatment with propiconazole (0.1 %) found more effective than tebuconazole (0.1 %) and carbendazim (0.1 %)
- Foliar spray of mancozeb 50 EC (0.3%), COC 50 WP (0.1%), carbendazim 50 WP (0.1%), difenoconazole 25 EC (0.03%) or propinpconazole 25 EC (0.15 %) thrice at preflowering, the fruit set and fruit maturity showed only 20.3 % or less fruit rot incidence.

Powdery Mildew: *Leveillula taurica*

Symptoms

White powdery coating appears mostly on the lower surface some times on upper surface yellow patches are also seen on upper surface. powdery growth also seen on young fruits, branches. Disease fruits may drop down.

Management

Spray Propiconazole 25% EC @0.1 % or Myclobutanil 10% WP @0.1 % or Tridemefon 25%WP@ 0.1 % to control powdery mildew.

Wilt:Fusarium oxysporum capsici

Symptoms

The plants showing symptoms of Fusarium wilt such as yellowing and wilting in younger leaflets, epinasty, stunting and yellowing of older leaves, brown vascular discoloration of the particularly in the lower stem and roots. The wilting symptoms appear as a result of severe water stress, mainly due to the vessel plugging/occlusion. The disease manifests at all growth stages with maximum severity at flowering and fruiting stage and results in partial to complete failure of crop.

Management

Use of resistant varieties, crop rotation and fallowing, field sanitation, deep ploughing, time and method of planting, Fusarium wilt of chilli can be successfully managed bysowing plants on ridges and avoiding excessive irrigation as wet soils were found to favour the disease. Soil solarization can also reduce the population of *Fusarium*

oxysporum capsici up to 0-15 cm depth in soil. Soil application of *Trichoderma viride* was highly effective against Fusarium wilt disease in chilli, which showed reduction in the wilt incidence.drenching with fungicide carbendazim+mancozeb @ 0.2%, carbendazim, Tebuconazole and thiophanate methyl were also found effective.

Chilli leaf curl:Chilli leaf curl virus

Vector: Whitefly (Bemisiatabaci)

Symptoms

The significant symptoms of chilli leaf curl are curling of leaf margin, reduction in leaf size, vein clearing accompanied by puckering, thickening and swelling of the veins.

Management

Three cultivars of chilli viz., Surajmukhi, Japani long and Pusa Jwala were showed highly resistant against leaf curl disease. Seed treatment with raw cow milk and *Trichoderma viridae* showed the reducing trends of chilli leaf curl disease incidence. Whereas seed treatment with imidacloprid 70 WS (5 gm/kg) along with two sprays of imidacloprid 17.8 SL (0.24 ml/lit) at 45 and 60 days after planting recorded least number of whiteflies and leaf curl virus per plant with significant increase of growth and yield.

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Effect of integrated plant nutrient management on climate change

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ABSTRACT

Soil is not an eternal supplier of nutrients required for crops growing on it. There is always a need to supplement the nutrient supply to crops through external sources like fertilizers and manures. Continuous use of inorganic fertilizers might harm the soil health though the nutrients are supplied in adequate amounts. The INM encourages the use of in house organic wastes, which also helps in keeping environment clean and safe. Emission of Green House Gases (GHGs) from various sources into the atmosphere causes rise in air temperature. The most prominent options for mitigation of GHGs emissions in agriculture are improved soil management practices viz. integrated plant nutrient management, precision agriculture (variable rate fertilizer technology), use of nitrification inhibitors, crop residue management, moisture restoration and restoration of crop productivity of degraded lands, which increase crop production per unit area, enhancing crop production and withdraw atmospheric CO_2 through enhanced photosynthesis.

Keywords: Climate change, INM, agriculture, GHGs

INTRODUCTION

The soil is a place for plants to grow-the factory that produces the plants which maintain human life. Soils and plants growing on them maintain the natural balance in the system and purify the air. Climate change is unavoidable and associated weather extremes such as high temperature and heat waves, increased frequency of drought and high intensity rainfall causing floods, are the issues of concern. Circumstantial evidences almost confirm researchers' early predictions of a changing climate and a warming world. The trend of changes also establishes the primary influence of increased greenhouse gas concentration on the global warming and the consequential events. The global mean surface air temperature has increased by about 0.85 [0.65 to 1.06] °C over

the period 1880 to 2012 (IPCC, AR5, 2014). Changes will vary from region to region. The global mean surface temperature is projected to increase further under all the representative concentration pathways (RCPs). This is because of the increase in the global abundance of the three key greenhouse gases (GHGs) namely, CO_2, CH_4 and N_2O in the atmosphere. The radiative forcing of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) is very likely (> 90% probability) increasing at a faster rate during the current era than any other time in the last 10,000 years. Thus, climate change is manifested basically in the following three different ways: (1) Increase in concentration of green house gases (CO_2, CH_4 and N_2O), (2) Global warming and (3) Increase in extreme weather events. Because of the higher abundance of the CO_2, the total radiative forcing of this gas is higher and thus is much talked about in context of climate change.

CHALLENGING CLIMATE CHANGE IMPACTS

To challenge the impacts of climate change, two types of measures are generally used: (1) mitigation and (2) adaptation. The IPCC defines mitigation as an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases. Some examples of mitigation measures include higher use of renewable energy, practicing energy efficiency, electrification of industrial activities etc. On the other hand, adaptation is the adjustment to the natural or human systems to a new or changing environment. Adaptation to climate change includes practices and measures that reduce the vulnerability to the effects of climate change. It also includes harvesting the most of any potential benefits or beneficial opportunities associated with climate change. Some examples of adaptation measures include reforestation, restoration of degraded lands, precautionary measures to avoid harmful effects of heat stress etc. However, certain measures can have both mitigation and adaptation value. For instance, conservation tillage can show a reduction in carbon emission can enhance the carbon storage in soil and at the same time can impart resilience to food production under drought conditions due to higher soil moisture retention. To eliminate or reduce the risk of climate change to human life and property, both policy instruments and technology must be used in the context of sustainable development.

Integrated plant nutrient supply / management (IPNS)

Integrated Plant Nutrient Supply / Management (IPNS) have been long associated with agriculture practice. However before Green Revolution, agriculture was mostly characterized by low input – low output system with less dependence on inorganic chemical fertilizers. Introduction of high yielding varieties and increase of cropping intensity led to widespread nutrient mining from soil and a negative nutrient balance in soils of major cropping systems. This led to laying much emphasis on the IPNS as the fertilizer response ratio decreased drastically in many South Asian countries. The IPNS is a system where the nutrient demands of crops are met from a combination of nutrient sources including chemical fertilizers, organics, biofertilizers and green manures. Thus the major components of IPNS are: Balanced fertilization, Chemical fertilizers, Organic

sources of nutrients including non-conventional sources, Crop residue management, Green manures, Biofertilizers

IPNS is a climate smart soil management system

The IPNS has a substantial role in reducing carbon foot print in food production systems and plays a vital role in imparting mitigation and adaptation value. Some of the basic principles by which IPNS governs the mitigation aspect in soil management systems include reduced N_2O emission, reduced CH_4 emission and increased soil C storage. At the same time, IPNS also adds adaptation value to the management system primarily through higher soil moisture storage so as to withstand drought conditions, better soil structure for favorable infiltration and water movement, increased biological activity to supply plant nutrients through altered rates of soil processes and finally through a higher biological productivity even under stress conditions. The commonly followed IPNS practices along with their mitigation and adaptation values are discussed below.

Site specific nutrient management: It is also known as need based fertilizer application where nutrients/fertilizers are added depending upon the plant demand and soil test value. It has mostly been used for N fertilizer management. Use of leaf colour charts and chlorophyll meter for N management in rice crop in Asian countries is one of the leading examples of need based fertilizer management and studies have shown a reduction in use of N by 12 to 25% in India without any yield loss (Ali *et al.* 2015).

Organic manures: In agriculture, organic manures such as farmyard manure, vermicompost, green manure, and azolla have been used in soil nutrient management depending on the availability of the resources and farmers' convenience. However, one of the major limitations of these manures is their low nutrient content and thus is required in bulk. Despite low nutrient value, organic manures improve soil quality by increasing the soil carbon content and enhancing biological activity. Manures like farm yard manures as are applied after a decomposition cycle adds stability to the C added to the soil. Manure addition enhances soil carbon sequestration (carbon sinks) and also enhances physical protection of soil C through better aggregation. However, enhanced soil carbon through addition of organic materials to soil does not always mean contribution to climate change mitigation. Conditions, where, carbon is stabilized or physically protected through aggregation actually add to the mitigation and adaptation value (Tesfai *et al*., 2016).

Biofertilizer application: Biofertilizers are products or formulations that contain living cells of different types of microorganisms and they are used either as seed or soil application. After being applied, the microbial cells multiply and eventually colonize in the rhizosphere or the interior of the plant and help in solubilising or increasing the availability of plant nutrients. Rhizobium is a symbiotic N fixer with legumes where as *Azospirillium* and *Azobacter* are free living N fixing bacteria. Phosphate solubilizing bacteria like Bacillus help in converting P from insoluble forms to soluble forms. Several studies report saving in N and P through use of biofertilizers, though the extent varies depending upon the soil and climate conditions. Tesfai *et al.,* (2016) reported a saving of

about 30% urea due to soil test based fertilizer application along with biofertilizers. The treatments having cyanobacteria (blue green algae) application apart from registering higher rice yields, showed lower methane flux as compared to the flooded rice. Reduced requirement of N from chemical fertilizers due to supplementation from biofertilizers is also likely to reduce the N_2O flux from rice ecosystems. From the point of global warming potential, CH_4 and N_2O are more potent than CO_2. Thus, use of biofertilizers can be considered to be a potential climate smart nutrient management strategy

No-till and conservation tillage

No-till system is the most widely studied agricultural management system to improve carbon economy. However, it depends on specialized planting equipment and herbicides. The major benefits accrued from a no-till system include accretion in soil C due to low disturbance of soil in absence of any tillage. The basic mechanism involved is higher aggregation which in turn gives physical protection to soil C. However, most of the studies have demonstrated that no-till can increase soil C, particularly at the soil surface (Six et al., 2004; West and Post, 2002). Further, to achieve a substantial gain in soil C, it is vital to maintain the soil with no-till systems without any interruption. Conservation tillage is a modified form of no-tillage system where tillage is practiced to some extent, but stores soil C using similar principle as that under no-till system. Despite the above, beneficial effects of no-till and conservation tillage systems are not conclusive. In the short term, controlling weeds and managing residue-borne diseases pose hinderances to a wider adoption of these systems (Giller *et al.,* 2009).

Cover crops and crop rotations

While conservation tillage systems protect soil C primarily due to low disturbances of soil and thus giving a physical protection to soil C, cover crops and crop rotations particularly with legumes supply C input to soil. Further, cover crops have shown benefits of suppressing weeds and reducing soil erosion and thus reducing the loss of plant nutrients through runoff or uptake by weeds. Some recent studies have demonstrated that more diverse crop rotations contribute to soil carbon and higher soil microbial activity (McDaniel *et al.,* 2014). Inclusion of different crops in a rotation releases greater variety of carbon compounds to soil and some of them have higher mean residence time. Crop rotations also break the monotony of specific cropping systems and associated problems and also explore nutrient demand from varied zones in soil profile.

CONCLUSION

Integrated plant nutrient management practices increases SOC content is likely to have beneficial effects on soil properties and functioning, although some could have little benefit when it comes to climate change mitigation. Combined applications of soil management technologies are likely to generate more climate smart agriculture co-benefits than applying a single soil management technology. Climate change is a reality that aggravates anthropogenic factors leading to severe soil degradation, declining soil fertility and agricultural productivity. The negative impacts of climate change need to be identified and concerted actions are needed. In order for soil management technologies

to be sustainable and applicable on a wider scale, the technologies must be mainstreamed into national policy making processes.

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Laminits in Horses–Prevention is Better than Cure

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Abstract

Horses have been domesticated since prehistoric times and hold a special place in our history and culture. It is the source of employment and income for the poor farmers and landless labourers. It also plays a significant role in elite sections of society, sports and national security. The managemental disease are the major problems in equine which imposes a heavy economic burden on farmers. There is a list of major managemental diseases reported in horses like equine rhabdomyolysis syndrome, big head disease, colic and laminitis. Out of all, laminitis is the second biggest killer of horses after colic. This condition is in utmost need of being promptly diagnosed to carry out a better approach for its prevention and management.

Key words- Laminitis, horse, prevention, managemental

INTRODUCTION

Horses have been domesticated since prehistoric times and hold a special place in our history and culture. Domestication of wild horses played a key role in the rise of larger human settlements and great civilisations. With the advent of modern means of transportation, utility of equines is decreasing resulting in decline in their population. Besides that, 98% of equine population in India is the source of employment and income to the poor farmers and landless labourers. Remaining 2% of the equine population plays a significant role in elite sections of society, sports (racing, polo) and national security (military and paramilitary forces).

The managemental disease are the major problems in equine which imposes a heavy economic burden on farmers and equine sector stakeholders. There is a list of major managemental diseases reported in horses like equine rhabdomyolysis syndrome, big head disease, colic and laminitis. Out of all, laminitis is the second biggest killer of horses after colic.It is a crippling condition which can be fatal in severe cases

Laminitis (often called **founder**) commonly affects horses, ponies, donkeys and mules. It has also been diagnosed in zebras and some cloven-hooved animals.It is the inflammation of the laminae of the foot – the soft tissue structures that attach the coffin

or pedal bone of the foot to the hoof wall. The inflammation and damage to the laminae causes extreme pain and leads to instability of the coffin bone in the hoof. It is an extremely painful condition and has a significant welfare implications for owners.

Once a horse has had an episode of laminitis, they are particularly susceptible to future episodes. Laminitis can be managed but not cured which is why prevention and management is so important.

Causes-

1) Diseases associated with inflammation
e.g. certain types of colic, diarrhoea, retained placenta, severe pneumonia
2) Endocrine (hormone) disease
e.g. Equine Cushing's disease (pituitary pars intermedia dysfunction; PPID), equine, metabolic syndrome, excessive pasture consumption
3) Mechanical overload (supporting limb laminitis; SLL)

Symptoms of Laminitis

1. Acute laminitis

For animals suffering acute laminitis symptoms generally come on very suddenly and are severe. The horse will show an inability or reluctance to walk or move and may possibly lie down, displaying an unwillingness to get up. The horse will be visibly lame especially when moving on a circle or on a hard surface, and will have an increased digital pulse in the foot. The horse, when standing, may well lean back on to its hind feet in order to relieve the pressure on its front feet. The horse will have pain in front of the point of frog and when walking may place its heels down first rather than its toes. There can also be symptoms shown vaguely similar to colic.

2. Chronic laminitis

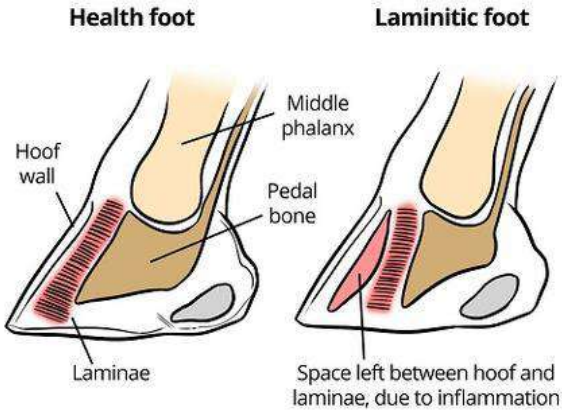
A horse with chronic laminitis will show signs of ongoing symptoms that are generally a result of a relapse from previous attacks.The horse's hoof will have the appearance of growth rings around the hoof wall, which generally indicates that it has suffered from laminitis in the past. However, these should not be confused with hoof rings, which are due to changes in nutrition or to stress.The heel will often grow faster than the toe and the white line in the hoof will have widened. The horse may well have a large crest, which runs along its neckline.Laminitis an inflammatory condition of the tissues (laminae) bonding the hoof wall to pedal bone in the hoof. It is often recurrent for individual horse

Warning signs of laminitis- bounding digital pulse, a hoof that's hot for hours, a distorted hoof shape, an increased heart rate, too little or too much foot lifting, apparent stretched or bleeding laminae, shortened stride, increased insulin level, obesity, diarrhoea, infection por inflammatory response.

Diagnosis

- Diagnosis is based on the clinical signs usually

- X-rays may be taken if there is concern that the pedal bone has sunk or rotated, or if the animal is not improving despite appropriate therapy
- Blood tests may be performed in cases where an underlying endocrine disease is suspected.



Treatment

Laminitis is a medical emergency and horses should be treated as soon as possible. Various medicine can be given to control the pain. Non-steroidal anti-inflammatory drugs (NSAIDs) such as phenylbutazone or flunixin and opiates like morphine and pethidine can be given.

- Acepromazine has traditionally been used to increase the blood supply to the feet.
- Use of ice to cool the feet may be beneficial in cases of laminitis associated with inflammation.

If the laminitis is the result of conditions, such as an endocrine disorder, that disease should be treated accordingly.

Potential complications following treatment

- Due to overweight bearing, the opposite limb may develop contralateral limb laminitis
- Abnormal hoof growth
- Repeated flare-ups of laminitis
- Increased predilection for developing hoof abscesses

PREVENTION AND MANAGEMENT

- Minimizing turnout, providing a deeply bedded stall or finding a turnout area that is of soft ground/sand with reduced grazing area
- Change in diet to a low carbohydrate/starch, minimizing grass intake (especially in the spring), soaking/steaming hay
- Corrective shoeing on a frequent schedule (every 3–5 weeks)
- Daily administration of anti-inflammatory medication (phenylbutazone (bute) or banamine) to help manage pain and make standing more comfortable

- Regular recheck radiographs (every 3 months to yearly based on your veterinarians recommendation)

CONCLUSION

Managerial diseases may impose an unnecessary burden on the equine sector stakeholders and may damage the economic growth associated with it. Laminitis is a complicated disease of which the origin is not clearly understood, hence the condition is in a desperate need of better understanding to pursue a streamlined approach for its prevention and control.

Solar Energy Schemes for Agriculture Sector in India

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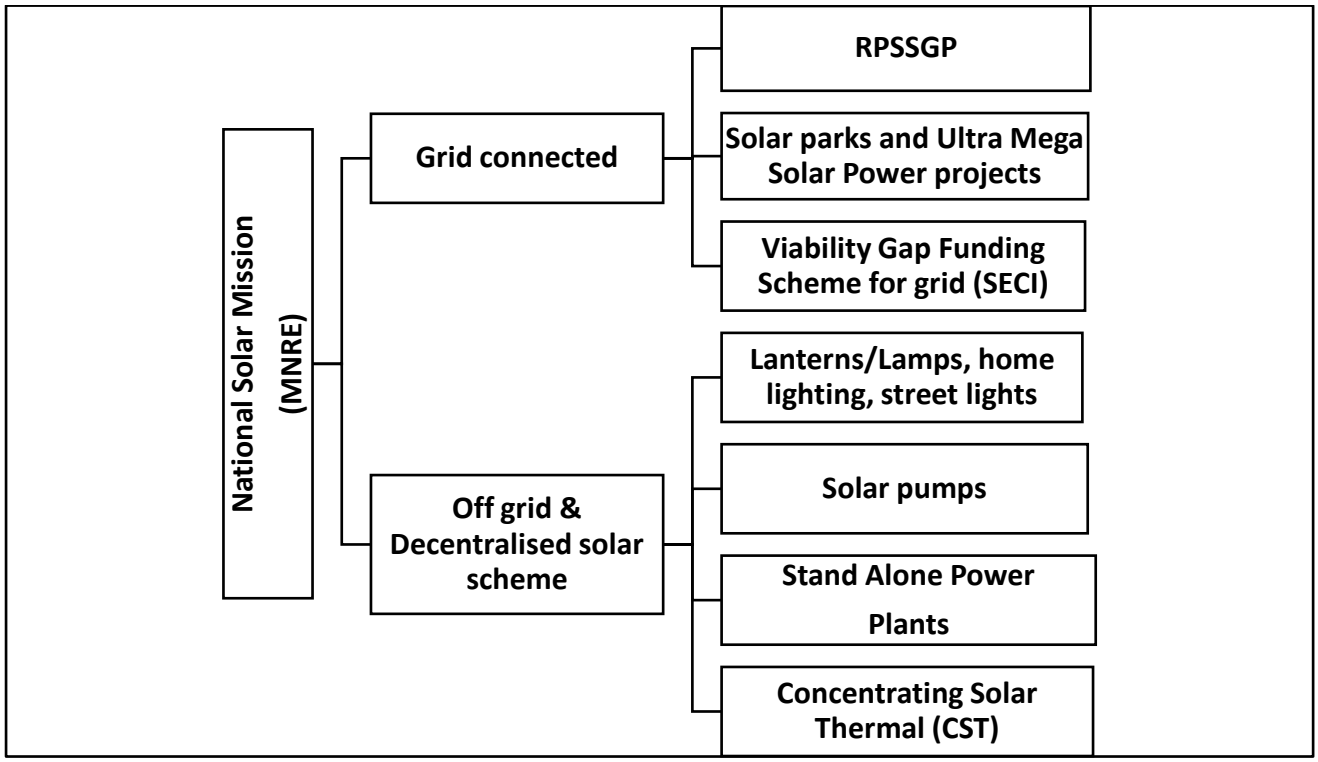
The application of renewable energy sources such as solar, wind and biomass is increasingly popular in the world since past decades inthe wake of global climatic change, volatile crude oil prices and limited amount of fossil fuels. Renewable energy sources can contribute to social and economic development, a secure energy supply, and reduced negative impacts on the environment and health (Edenhofer *et al*., 2011). In particular, solarenergy industry is growing in many countries especially in China, Europe and USA. With the abundant solar radiation of 4 - 7 kW/m^2 daily average radiation for about 1500–2000 sunshine hours per year available, solar power have a potential to meet the energy demand in India. The National Solar Mission (NSM), launched in 2010 by Government of India played a crucial role in scaling up of solar energy use. Through this mission government aimed to generate 100 GW of solar power by 2022.

Out of total installed capacity of 310 GW power in India, renewable energy secured second position with 14.8 per cent share after thermal (69.4%). The total potential for renewable power generation in the country as estimated at 1096 GW in which solar power occupy the highest share (68.33%) followed by wind power (27.58%) small-hydro power (1.80%) and biomass power (1.60%) (CSO, 2019). Also, the total installed capacity of renewable energy source as on 31.10.2018 is 73 GW in which solar has 33.15 per cent share next to wind (47.70%). This means renewable sources, particularly solar, has a greater role in meeting present and future energy demand in India.

The schematic representation of major solar programs under NSM is given in figure 1. The solar power in India is being promoted through grid connected solar power system, and off-grid solar systems like roof top solar system, solar lighting system, Solar Photo Voltaic (SPV) irrigation pump. Recently, solar photovoltaic system has become attractive and affordable for pumping irrigation water in locations due to its long life and rapid decline in cost. The solar-powered irrigation system is one of the best options which do not require expensive maintenance and does not emit green-house gases as compared to that of diesel or propane-based water pumping systems. The PV array water pumping units for irrigation and drinking water in remote areas,

where other sources of power not available, are found to be the most feasible and economically viable (Posorski, 1996).

Figure 1: Solar schemes in India



RPSSGP: Rooftop PV and Small Solar Power Generation Programme
SECI: Solar Energy Corporation of India
Source: Based on Annual report, Ministry of New and Renewable Energy (MNRE)

SCHEMES FOR SOLAR POWERED IRRIGATION SYSTEM

To meet the ambitious target of 100 GW in 2022 application of solar in agriculture is important as it provides livelihood to more than 50 per cent of population.The Ministry of New and Renewable Energy (MNRE) had introduced SPV programme for irrigation during 2014-15 in coordination with Ministry of Agriculture through State Nodal Agencies. MNRE provides 30 per cent capital subsidy to the states for installation of solar pumps while state wise subsidy will be varying. For example, Rajasthan, a front runner in the installation of SPV pumps, provide 56 percent of subsidy to the farmers having at least 0.5 hectare of land with drip irrigation. Other states like Andhra Pradesh, Bihar, UP etc., cover 45-60 per cent of capital cost through subsidies. About 2.37 lakh solar pumps installed under the programme till now (MNRE, 2019). Rajasthan, Chandigarh and Andhra Pradesh are the top three performers in the installation of SPV Pump. Other major agricultural states like Uttar Pradesh, Odisha, Gujarat, Tamil Nadu and Karnataka also have considerable amount of share in the SPV installation.

In 2018, new scheme KisanUrja Suraksha evamUtthamMahabhiyan (KUSUM) was introduced which is having three provisions:

- Installation of 10,000 MW of decentralised ground mounted grid-connected renewable power plants in the rural areas. The farmers, cooperatives, panchayats, or FPOs can install grid-connected solar power plants having capacity ranging 500 kW - 2 MW in their land.
- Installation of 17.50 lakh standalone solar powered agriculture pumps of individual pump capacity up to 7.5 HP will be done.
- Solarisation of existing grid-connected agriculture pumps to enable farmers to sell surplus solar power generated to DISCOMs to get extra income.

In 2020 budget, the government announced the expansion of KUSUM scheme to provide 20 lakh farmers in setting up stand-alone solar pumps. The solarisation of existing water pump sets has expanded to another 15 lakh farmers. In addition to this, the farmers who have fallow or barren land can set up solar power generation units and also sell surplus power to the solar grid.

This will benefit for both farmers as they gain an extra income from surplus saleof energy and for state government as it will add to their minimum percentage of Renewable Purchase Obligation (Shah *et al*, 2014).

The KUSUM scheme have a great potential in India in meeting energy demand and reducing rural poverty. Linking roof top solar and stand-alone solar pump to grid is very good initiative which can be used for meeting rural energy demand and for achieving the 2022 target. At the implementation stage, factors like land availability, problems in net-metering, operational difficulties of distribution companies (DISCOMs), should be taken care of. Theavailabilityof technical assistanceat grass root level, proper monitoring and supervision of grid connected solar systemshould also be considered.

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Significance of Supplementing Area Specific Mineral Mixture in dairy Animals

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ABSTRACT

The productivity of animals depends on balanced ration by providing proper amounts of all important nutrients to fulfil their requirements for different physiological function. Assess of minerals deficiency and various metabolic disorders in all types of dairy animals have been observed due to lower mineral content and poor bioavailability of essential macro and micro minerals from different feed staffs. The problem associated with deficiency has been noticed in the animals differs with the different region due to different composition of the soil, cropping intensity, the pattern of precipitation and soil erosion etc. It is therefore very important to understand the basis of mineral nutrition as also to fulfil the requirement of the animals to avoid the problem of deficiencies or excesses, to maintain the productivity of animals. The concept of an area-specific mineral supplement is a new approach of low input with high output for the farmers to improve the productivity of animals.

Keywords: Area-specific mineral mixture, Dairy animals, Productivity

INTRODUCTION

In India, animal feeding is traditional and mainly depends upon locally available feed resources. Crop residues which constitute a major portion of diet are poor in essential minerals. It also contains various anti-nutritional factors like silicates, oxalate and phytic acid, which further inhibit their utilization. Therefore, their supplementation through mineral mixture is paramount importance and benefits of the feeding of the mineral mixture to animal improves growth rate, the efficiency of feed utilization, milk production, reproductive efficiency, resistance against infectious diseases and reduces inter-calving interval. It helps in increasing the productive life of the animal and minimizing the incidence of certain metabolic diseases. As mineral deficiencies in the

ration of animals vary with agro-climatic conditions so proper assessment helps the development of suitable area specific mineral mixture for supplementing the ration of animals effectively and economically. Providing area-specific mineral mixture (ASMM) based on the deficiency of minerals in soil, plant and animal in different agro-climatic zones is the most appropriate and cost-effective method of mineral supplementation. The approach of free choice mineral supplementation could sometimes lead to deleterious effect, as some of the minerals may be available in excess than requirements affecting utilization of other minerals, like excess of selenium affecting sulphur utilization, excess of molybdenum and sulphur reducing copper absorption and excess of iron disturbing copper metabolism. The method of supplementing only the most deficient minerals through area specific mineral mixture by assessing the mineral content in the soil, feeds and fodders and animals in different agro-climatic zones appears to be the best approach.

EFFECT OF MINERALS ON REPRODUCTIVE PERFORMANCES

Mineral supplementation has been reported to improve the reproductive efficiencies in animals. Along with different minerals, different forms of minerals also put their impact on the reproduction of animals. The different inorganic and organic forms of Cu, Zn, Mn and Se examined and found an increase in the conception rates and days to the first service by replacing inorganic minerals with their organic form. Similar improvements are observed by replacing inorganic sulphate salts of Cu, Mn, Zn and Co with organic forms. Improved reproductive performance is observed in inorganic and complexed organic trace minerals supplied dairy cows at or above NRC (2001) requirements. Silent oestrus of buffaloes can also be ameliorated through area-specific mineral supplementation. Deficiency of a single or multiple minerals or their imbalances leads to delayed puberty, delayed ovulation, lower conception rate, high embryonic/foetal losses and prolonged postpartum anoestrous. The supplementation of ASMM has been reported to improve the reproductive efficiency in buffaloes and 70per cent buffaloes showed normal cyclicity. Dietary deficiency of macronutrients is well combated by commercially available feeds and hence optimum supplementation of all the microminerals results as the stimulus for ovarian rebound and initiation of ovarian activity. Higher productive and reproductive performances are noticed in dairy animal supplemented with mineral mixture enriched with some important microminerals. Organic iron supplementation during late pregnancy and early lactation have been found to increase productive and reproductive performances in animals. Supplementation of Molybdenum caused the delayed onset of puberty, reduced conception rate and c anoestrus in the animal. It is proposed that the effects of Mo are associated with reduced release of luteinizing hormone that may be due to changed ovarian steroid secretion. Zinc has roles in the reproductive function of dairy animals, particularly by reducing the risk of abortion and abnormal oestrus cycle and decreasing days to the first oestrus. Some researchers found that copper improved reproductive performances of Holstein cattle and Mn improved bovine sperm activity. Therefore feeding dairy animals with organic trace minerals may improved fertility. In

particular, beneficial effects on reproduction have been reported in animals fed organic trace minerals during late gestation. The deficiency of certain minerals like Ca, P, Cu, and Zn in dairy animals has been reported in field conditions and the area-specific mineral mixture improved reproductive efficiency. Some of the minerals, especially Cu, Zn, Fe, Se and Mn work synergistically to reduce the oxidative stress through non-enzymatic mechanisms. Thus, nutritional supplementations play an important role to improve the production and reproduction and health of animals. The lower level of Ca, P, Mn, I, Co, Fe, Cu and Ca: P ratio has been reported in anestrus cattle and buffaloes when compared with those exhibiting normal oestrus.

EFFECTS OF MINERAL MIXTURE SUPPLEMENTATION ON MILK COMPOSITION AND MILK YIELD

Dairy animals with minerals deficiencies are producing low milk and subsequently, show increased milk production after mineral supplementation. Improvement in milk yield is observed due to supplementation of energy with the mineral mixture in lactating animals. Since milk is rich of several minerals like calcium so, in high yielder animals, these minerals oozing out through the milk and animals become deficient of these minerals and production and health of animal severely affected. Supplementation of these minerals in the diet of lactating animals has been reported to improve the overall performance of animals. Zinc and vitamin A have a role in maintaining the health and integrity of epithelial tissue of mammary gland due to its role in cell division and protein synthesis. Zinc is required for the incorporation of cysteine into keratin for protection of teat canal. The keratin lining of the teat canal stop the entry of bacteria and prevent their movement into the mammary gland and thus decreasing mammary gland infection (mastitis). The ration that is balanced for crude protein, energy, various minerals improves the average daily milk yield and milk composition in both cows and buffaloes.

CONCLUSION

Supplementation of area-specific minerals mixture can improve the mineral status and hormonal profile of animals. It increases the reproductive efficiency of animals thus maintain the overall productive and reproductive performance of animals.

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Crop Rotation – Key to Success in Organic Farming

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ABSTRACT

Rotation of crops is one of the important components for success in cropping systems since it relates to usage of agricultural field in an efficient way. Among the various agronomic approaches towards successful agriculture, cropping pattern and rotation of crops are the oldest. With an increase in the area under organic farming, crop rotation is likely to play a critical role in water, nutrient, weed, pest and disease management in organic agriculture. Inorganic fertilizers and pesticides which are known to provide immediate effect on nutrient supply and pest control are not used in organic farming. Instead, organic manures, biofertilizers, biopesticides and bioherbicides are used. This can be either complemented or supplemented by selection of succeeding and preceding crops on scientific basis.

Keywords: Crop rotation; Nutrient Management; Organic Farming; Plant Protection; Weed control.

INTRODUCTION

Rotation of crops is the practice of using the natural, biological and physical properties of crops to benefit the growth, health and competitive advantage of other crops (Mohler and Johnson, 2009). Soil physico-chemical properties and beneficial microflora are also benefited during this process. Ultimately, proper crop rotations can lead to more productive and self-sustainable organic farming. A comparative study on organic and conventional farming across the globe indicated more diversified crop rotations in organic farming (Barbieri et al., 2017). However, in most cases, crops are not chosen based on the knowledge on biology and biochemistry of soil-plant-environment interactions. Crop rotations for longer period of years may not work, since there will be variations in weather conditions, water availability for irrigation and fluctuations in market price of the agricultural produce. Hence, shorter cropping plans of 1-2 years

would be wiser and it requires knowledge on soil nutrient status, pest and pathogen load before and after cultivation of a given crop. Choice of crops in crop rotation sequence is critical and the wrongly chosen crops may lead to nutrient imbalance, outbreak of pests or pathogens, damage by weeds and toxic biochemical effects from root exudates. Most of the times, farmers are surprised of poor growth or yield of their crops during a rotation due to the aforementioned reasons.

CROP ROTATION BASICS

Crop rotation is basically to sustain the farm productivity. The rotation design for an organic cropping system recommended by Lampkin (1990) argues that the starting point for the crop rotation plan should be based on soil parameters and climatic conditions. The basic guidelines to be considered for crop rotation are:

1. Crop rotations should include taxonomically different crops (crops belonging to different botanical families)
2. Deep rooted crops should be followed by shallow rooted crops
3. Crops with high root biomass to be rotated with those having low root biomass
4. Nitrogen fixing and nitrogen demanding crops have to be rotated
5. Inclusion of green manure and cover crops
6. Rotation of fast growers and slow growers
7. Host and non-host crops for pest and diseases based on proper surveillance

SOIL NUTRIENT MANAGEMENT

Legume crops supply nitrogen for succeeding crops since they can fix atmospheric nitrogen through root nodules and the rhizobial bacteria association. Nitrogen fixed by legumes vary based on crop, variety, soil management system, climate etc. Basically, the amount of nitrogen contributed by legumes varies between 20-100 kg nitrogen per acre. Cruciferous crops like cabbage, cauliflower, radish and carrot are known to leave more nitrogen in the soil in the form of crop residues. Cereals and millets produce fine roots and also secrete substances which make the soil to form clumps. The root system decomposes slowly and leads to slow supply of organic nutrients for the next crop. Among the vegetables, beans, beet, carrot, peas, radish etc are crops with less nutrient requirements. Cucumber, brinjal, pepper, pumpkin, squash, sweet potato, water melon etc are categorized as medium, whereas, cabbage, cauliflower, corn, lettuce, potato and tomato are highly demandful for nutrients. A sample of the order of deep rooted to shallow rooted crops: alfalfa, soybean, sorghum, corn, wheat, oat, barley, turnip, pea, potato. Deep rooted crops absorb nutrients from deeper soil and the residues of these crops when returned to soil provide nutrients to the future crops. Knowledge on export and import of nutrients to soil (how much a given nutrient is added and how much is depleted) in a cropping system has to be derived based on soil nutrient testing from time to time. Such follow-up of soil nutrient status will help in choice of crops, thus balancing of nutrients and reduce the amount of external inputs like organic manures and biofertilizers.

PEST AND DISEASE MANAGEMENT

The most inexpensive means of pest and disease management in organic farming is – growing of non-host crops. Crop rotation is preventive than a curative approach in pest and disease management. Rotation of crops belonging to different botanical families results in breaking of pest and pathogen life cycles. Due to the absence of host, pests and pathogens starve for nutrients and remain controlled. However, knowledge on the pests and pathogens, their life cycles, host range, alternate and collateral hosts, reproduction and multiplication biology, spreading etc are required. Most of the pest and pathogen stages remain in the crop residues. Some of the pathogens can survive as saprophytes feeding the decaying organic matter. Crop rotation can help to suppress the non-saprophytes like *Pythium* sp and *Fusarium* sp. Facultative parasites are originally saprophytes which can cause disease in the presence of live host. On the other hand, facultative saprophytes are originally parasites which can survive as saprophytes in the absence of living host. Hence, facultative parasites may be difficult to control by crop rotation. Incorporation of green manure, green leaf manure and partly decomposed organic manure could help in proliferation of these facultative parasites and can cause severe disease incidence in succeeding crop in the rotation.

Some of the pests and pathogens have broad host range. *Rhizoctonia solani* can affect cereals like rice and ragi, pulses, vegetables and oil seed crops. The whitefly *Bemesia tabaci* can infect 700 plant species in the world. The contemporary alarming pests such as fall army worm (*Spodoptera frugiperda*) and the spiralling whitefly (*Aleurodicus rugioperculatus*) also have a broader host range of corn, rice, millets, sorghum and fruit crops, cassava, palms, woody ornamentals respectively (Kumar et al., 2018; Nagoshi et al., 2020). Root knot nematodes have wide host range. Sorghum or other millets in the rotation along with better weed control will bring down the population of nematodes in soil, since some of the weeds are hosts for this nematode.

Crop rotation can be successful in controlling most of the narrow host range pests and pathogens. Nevertheless, even for the broad host range pests and pathogens, non hosts can be avoided in the rotation. *Phytopthora capsici* causes blight in cucumbers, pepper, tomato, brinjal and beans. Cereals are better option in a rotation. Rotation of cruciferous and non-cruciferous crops is essential to control pests like diamond back moth in cabbage. Rice fallow pulses reduce pests on succeeding rice crop. In cotton, crop rotation is one of the major components of integrated pest management. Strawberry – alfalfa rotation is known to have better control of strawberry plant bug. Crops like legumes and crucifers stimulate growth of beneficial bacteria in the soil which can suppress pests and pathogenic organisms either directly by hydrolytic enzymes and toxins or by inducing systemic resistance in crops. The toxic substances in the root exudates of mustard family crops contain chemicals like isothiocyanates which are involved in suppression of pests and pathogens in soil. These are refereed as pest and disease suppressive crops. Glucosinolate content varies with crop species and with

varieties within a species. Before one month of planting a crop, incorporation of seed meal from cruciferous crop into the soil was found to suppress soil borne pathogens (Mohler and Johnson, 2009). When a pest or pathogen incidence is severe, longer crop rotations may be needed to reduce the pest and pathogen load in the field. A minimum of two year period is required between wheat crops to reduce leaf spot disease. Rotation with a fallow period in between can be a better strategy to control pests and pathogens with wide host range.

WEED CONTROL

Crop rotation involves cultivation of one crop after another and effective utilization of the agricultural field. This cultivation-harvest-cultivation avoids weed growth to some extent since the field is occupied and dominated by agricultural crop. Research studies revealed that more the crop diversification in a rotation, less will be the problem of weeds (Liebman et al., 1993). The agronomic and cultivation practices vary from crop to crop which will interfere in the life cycle of weed species. Crop rotations with summer-ploughed fallow was found to be effective in reducing the weeds. Ploughing damages the seeds and rhizomes of weeds. In long duration crops, the weeds would flower and set seeds before the crop matures. Hence, rotation of long and short duration crops is recommended in such weed-prone fields. Similarly, direct see4ded crop should be rotated with transplanted ones. In crops like onion and carrot which have small foliage and less shade, weeds will be more and these crops are considered as poor competitors to weeds. The succeeding crops in the rotation should be fast growing crops like tomato or vine crops (spreading on the ground). Better crop canopy suppresses the weed growth by preventing the sunlight reaching the soil surface in enough amount for the weeds to grow. High density planting of crops can also reduce weed problem. Legumes and green manures can be used as cover crops with higher seed rate. Cover crops can also be grown as intercrop during the later stages of the main crop to avoid late-emerging weeds. Suppression of weeds may take few years as it takes time for the weed seed-bank to decline in the soil.

CONCLUSIONS

The popularly followed practice is cultivation of same sequence of crops repeated multiple times in a locality over several years. The reasons include i) demand based marketing strategy of the farmers and ii) habitual crop selection in locality and iii) past experience. To avoid poor performance of the crops and crop failures due to soil nutrient imbalance, pest and disease incidence, weed growth etc, proper crop rotation based on scientific awareness is essential. In organic farming, since data on crop rotations and plans are required for certification, selection of crop sequence should be done based on precise soil nutrient testing between crops, pest and disease surveillance. In addition to the clever crop selection for rotation, suitability to the locality and soil type, ability of the farmers to balance between high revenue and low revenue crops have to be considered during the crop sequence plan. Both the scientific

and non-scientific factors such as market strategy and sustained revenue, suitability of crops to the soil type and climate, knowledge on the soil-plant-environment interaction, pest and pathogen biology are needed to ensure profitable cropping system in organic agriculture.

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Pradhan Mantri Fasal Bima Yojana (PMFBY): A Tool for Agricultural Risk Management

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ABSTRACT

Indian economy is largely an agrarian economy as income from farm sector determines the fate of other sectors in the country. Thus, it is necessary to safeguard the farm sector from various production risks resulting from natural calamities and disasters. Though, the State Government provides some relief to the affected farmers through the Disaster Relief Fund but it is not enough to cover the losses to the crop. Therefore, there is a strong need to broaden the insurance policies for agricultural crops and their production.In such a scenario, agricultural insurance schemes come into the picture to help the farmers in agricultural risk management.Crop insurance is a financial mechanism to minimize the impact ofloss in farm income and protecting farmers against variations in yield by factoring in a large number of uncertainties which affect the crop yields.

Keywords: Risk, Agricultural insurance

1. INTRODUCTION

India is a land of farmers where around 60% of the population directly or indirectly depends upon agriculture sector for their basic, financial and other needs. The agriculture sector contributes 18% to India's GDP (Anonymous, 2019-20) and plays a dominant role in generation of employment opportunities in the country. According to 2011 Agriculture Censes of India, around 61.5% of the Indian population is rural and fully dependent on agriculture and out of which maximum are marginal farmers i.e. the farmers having less than 1 hectares of land. However, the percentage of marginal households has come down from 62.9% in 2000-01 to 22.5% in 2010-11which indicates that due to certain reasons, the marginal farmershave sold their land and moved out of agriculture. This also indicates that may be the agriculture alone is not capable to meet their basic needs and probably the people have gone to cities in search of better jobs or better livelihoods.

The agriculture sector is subjected to many risks and faces manifold problems such as rainfall irregularity, temperature fluctuations, snowfall, storm, flood, drought, crop

failure, non-remunerative prices for crops, poor yield, poor return, etc. The farmers are vulnerable to these agriculture risks as these not only jeopardize the farmer's livelihood and incomes but also destabilize the agriculture sector, Thus, the management of risk in agriculture is one of the major concern for solving the problem of poverty among the farmers. In order to mitigate these risks, the Government of India (GoI) hasmade various efforts such asintroduction of crop insurance scheme soon after the Independence in 1947. According to Agriculture Insurance Company of India (AIC), 2008 "Agricultural insurance is a means of protecting the agriculture against financial losses due to uncertainties that may arise agricultural losses arising from named or all unforeseen perils beyond their control". There are two major categories of agricultural insurance viz. single-peril coverage which offers protection from single hazard and multi-peril coverage which provides protection from several hazards.

2. EVALUATION OF CROP INSURANCE SCHEMES IN INDIA

After independence, a study was conducted during 1947-48 to know that whether insurance should follow an "individual approach" or "homogeneous area approach". The study favoured "Homogeneous Area Approach" means the approach which is based on defined areas such as a district, a block or any other smaller bordering area. This approach is practically all risk insurance but there are delays in compensation payments. However, the individual farm based insurance provides accurate and timely compensation. The first "individual approach" crop insurance scheme was launched in 1972 on H-4 cotton crop which later included groundnut, wheat and potato with coverage of only 3110 farmers for a premium of Rs.4.54 lakhs against claims of Rs.37.88 lakhs (Singh, 2010). This scheme was later dissolved in 1978 for being unsustainable. Then, in 1979-80, the Pilot Crop Insurance Scheme (PCIS) was launched by the General Insurance Corporation of India (GIC)based on "area approach"for providing insurance cover against a decline in crop yield below the threshold level. This scheme was implemented till 1984-85 and the premium paid by the policy holder was shared between General Insurance Corporation and State Governments in the ratio 2:1. During this period, it covered 6.27 lakh farmers for total premium of Rs.196.95 lakhs againstclaims of Rs.157.05 lakh (Singh, 2010). Later, in 1985-86, Comprehensive Crop Insurance Scheme (CCIS) was implemented for 15 years. This scheme was based on the "area approach" linked with short-term credit and was compulsory for loanee farmers in the participating states and union territories with coverage of 763 lakhs farmers for a premium of Rs.404 crores against claims of 2303 crores (Bhat*et al.,*2013). Its successor, the National Agriculture Insurance Scheme (NAIS) also known as Rashtriya Krishi BimaYojana (RKBY) was introduced in the Rabi season 1999-2000. This scheme was based on the both "area approach" for widespread calamities and "individual approach"for localized calamities and was implemented to increase the coverage of farmers including both with loans and without loan (Bhat*et al.,* 2013). The implementation of this scheme was taken over by Agricultural Insurance Company of India Ltd (AIC) in December, 2002. Further, Modified National Agriculture Insurance Scheme (MNAIS) was implemented on a pilot basis in 50 districts from Rabi 2010-11.

This scheme was compulsory for loanee farmers and voluntary for non-loanee farmers (Nayak, 2016). However, despite the modification, the scheme failed to cover all farmers.Finally, in February 2016, the Prime Minister of India launched a replaced scheme of NAISnamed The PradhanMantriFasalBimaYojana (PMFBY). PMFBY is one of the major management strategies to mitigate agriculture risk to greater extend and is regarded as an essential part of well-established different agriculture programmes, designed to provide protection to farmers against physical crop failures due to weather and other unavoidable natural hazards.

3. PRADHAN MANTRI FASAL BIMA YOJANA(PMFBY)

The PMFBY is a new crop insurance scheme that improved upon its predecessors making it easier for the farmers to avail crop insurance and enhance coverage. This scheme operates on an "area approach" basis. Thus, all farmers belongs to a particular area must pay the same premium and have the same claim payments. The area approach reduces the risk of moral hazard and adverse selection.Under this scheme, horticultural crops, commercial crops, *Rabi* crops and *Kharif* crops are considered eligible for insurance but at different rates. The main objectives of this scheme are given as follows:

a) To provide a measure of financial support to farmers in the event of a crop failure as a result of natural calamities such as drought, flood, etc.
b) To stabilise the income of farmers to ensure their continuance in farming.
c) To encourage farmers to adopt innovative and modern agricultural practices.
d) To ensure flow of credit to the agriculture sector; which will attribute to food security, crop diversification and enhancing growth and competitiveness of agriculture sector besidesprotecting farmers from production risks.

3.1 Coverage of farmers

The scheme covers loanee farmers (i.e., those who possess Crop Loan account/ KCC account), non-loanee farmers (on a voluntary basis), tenant farmers, and sharecroppers (Mathur& Gupta, 2019). The coverage of the non-loanee farmers has increased from 5% in 2015-16 to 42% during kharif 2019, which shows the acceptability and progress of the scheme on voluntary basis.

3.2 Implementing Agency

This scheme operates under the guidance and control of the Department of Agriculture, Cooperation & Farmers Welfare (DAC&FW), Ministry of Agriculture and Farmers Welfare (MoA&FW), Government of India (GoI) and the concerned State in coordination with various other agencies viz., financial institutions like Commercial Banks, Co-operative Banks, Regional Rural Banks and their regulatory bodies, Government Department viz. Agriculture, Co-operation, Horticulture, Statistics, Revenue, information/ science & Technology, Panchayati Raj, etc.Some of the salient features of this new scheme are gives as follows:

a) Farmers have to pay lower premiumsof 2% of the sum insured for all *Kharif* crops, 1.5% of the sum insured for all *Rabi* crops, and 5% of the sum insured for annual commercial and horticulture crops with no upper limit on Government subsidy.

b) PMFBY mitigates various risks such as sowing/planting risks, loss to standing crop, post-harvest losses, localised calamities and crop loss due to attack by the wild animals.

c) PMFBY uses innovation technology like remote sensing drones, smart phones and GPS technology for estimating the crop losses instead of crop cutting experiments (CCEs) which were used traditionally to estimate the crop losses.

3.3Coverage of area and farmers under PMFBY

According to Department of Agriculture, Cooperation and Farmers Welfare; in India 26.58%, 28.97%, 26.13% and 26.35% of area was insuredunder PMFBY in the year 2015-16, 2016-17, 2017-18 and 2018-19, respectively. Under PMFBY, 161730664 numbers of farmers were covered in Rabi 2018-19 out of which 44198704 numbers of farmers get benefitted. Also in this scheme, 5508635 numbers of claims are reported during 2018-19 out of which 5241268 numbers of claims are paid. An allocation of Rs. 15695 crore in the 2020-21 budget had been made under PradhanMantriFasalBimaYojana which was Rs. 5500 crore in 2016-17 (Anonymous, 2020).

4. CONCLUSION

Risk is an inherent part of agriculture. Thus, crop insurance is a wonderful tool which not only provides a cushion of comfort to the farmers in a situation of crisis but also brings about confidence among the farmers to grow better crops which can increase their overall yield and raise their standards of living. PMFBY is a pioneering crop insurance scheme which aims at providing an edge over earlier schemes.This scheme is definitely going to be a boon for the farming community. This scheme makes efforts to addressing the needs of the farming community and enhancing the overall efficiencies and competitiveness of the agriculture sector. This also signifies the tremendous potential of agriculture insurance in the country which can mitigate the adverse impact of uncertainties and risk on the farmers. Although, it increases the financial burden on the part of Government due to its lower premium rates as compared to earlier schemes but it is beneficial from the farmers; point of view.So, it is important for us to make an efforts to increase the awareness among the farmers to get into PMFBY crop insurance scheme so that there will be some amount of assured income for them in case of any unexpected loss in production process.

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Role of Agricultural Extension and Advisory services in attainment of food security amid COVID-19 in India

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ABSTRACT

Agricultural extension and advisory services can make notable contributions to minimizing the impact of COVID-19 in the developing nations like India. Agricultural extension advisory services need to rapidly "innovate from within" to ensure an effective andefficient response to COVID-19. Such innovations include strengthening the coordinationand governance of the pluralistic networks of extension agencies made up of public and private actors, producerorganizations, farmer groups and networks, advances in digital extension, while using allavailable and accessible information channels and facilitating and entering intopartnerships with many (often non-traditional) stakeholders in the agricultural innovation system to attain the food security in India.

Keywords: Agricultural Extension, Advisory services, COVID-19, Food security

INTRODUCTION

Governments across the country face numerous challenges related to mitigating the catastrophic health effects and protecting human lives, ensuring adequate food supply and the functioning of services to the neediest ones. Impact of COVID-19 pandemic in India is rising every day and affecting the farming community with the massive trade and economic disruptions. In the context of present disruptions and impending threats to the food supply chain, the COVID-19 outbreak has created extreme vulnerability in the agriculture sector. Therefore, mobilizing all available resources, organizations and stakeholders from both the public and private sectors and civil society is essential in order to ensure effective and timely response.Agricultural Extension and Advisory Services (AEAS) play a vital role at the forefront of the response to the pandemic in rural agrarian areas. However, with the advent of innovative technology dissemination

methodologies, agricultural extension functionaries need to rethink and alter their way of working rapidly to respond to the emergency context within the government regulations.

Changing demands and the role of agricultural extension and advisory services during COVID-19 pandemic:

The world is struggling to fight the COVID-19 pandemic, especially in developing countries like India, where the rural population may face a dual burden: lack of information and health services coupled with poverty will expose them to health risks as well as the disastrous socio-economic consequences of the crisis. Meanwhile, the farmers need to continue working in agriculture to ensure not only their livelihoods but also national and global food supply and, in turn, food security.The impact of COVID-19 is not uniform across the globe and all agricultural commodities. Different strategies and measures need to be taken to safeguard food security and address bottlenecks along the food supply chains. While the disruption in food supply chains mostly concerns logistics, labour, transportation and marketing of perishable and fresh products due to restricted mobility and lockdowns, the COVID-19 outbreak leaves the agriculture sector in an extremely difficult situation that puts food supply at serious risk for 2020 and beyond (Carberry and Padhee, 2020)

The challenges faced by the Indian farmers with respect to agriculture and allied sectors include: access to agricultural inputs, the availability of the labour force at crucial times of crop production and harvesting, marketing, transportation and other necessary services. The poorest, most vulnerable populations as well as smallholder producers are those hardest hit by the COVID-19 outbreak whose household incomes and food security are at risk. Rural communities and producers are always facing the problem of information lacking and support from extension functionaries. Hence, there is increasing demand to ensure that they have access to basic agricultural services with reliable, timely and accurate information during this unprecedented emergency.

The pluralistic innovative networks of extension functionaries including public, private sector, nongovernmental organizations (NGOs), farmer producer organizations (FPOs), farmer groupsand commodity interest groups (CIGs) etc., with the help of digital media tools has proven very instrumental for the central and state governments as well as for rural agrarian communities during and after the pandemicin bridging the information gap from and to the field. These extension functionaries will play a significant role in raising awareness about COVID-19 in rural areas to reduce the spread of the pandemic while ensuring that rural producers have appropriate and reliable information and services to sustain their agricultural growth, both during and after the crisis.Their actions must adhere closely to the regulations and guidelines of the respective state governments. As long-term trusted and close associates of farmers and rural communities, extension functionaries are in an inimitable role to assess the situation on the ground, provide tailored services, and advise the governments who need to take swift and effective action to ensure the nation's health, food supply and security.

SUGGESTED APPROACHES FOR PROMPT RESPONSE DURING THE COVID-19 PANDEMIC

In this tough time, the role of agricultural extension and advisory services is much more precarious than before in bridging the complexities of local communities with the government actions, and helping rural farmers to overcome new challenges for which they cannot find solutions on their own, ranging from continuing to work to protect their health, producing food and maintaining their earnings amid the disrupted supply chains. Extension functionaries who provide the advisory services need to react rapidly to the evolving situation and alter their approach to respond to the emergency context within the government protocols.

Adaptation of agricultural extension and advisory services dissemination approaches:

- Coordinate activities among that extension officials including government, private, non-governmental organizations, FPOs, etc. Crises such as COVID-19 require timely dissemination of a wide range of services, and the intensive intervention of various types of extension advisory services is vital.
- Go digital: digital media tools and technologies enable information flow despite physical distancing and mobility constraints. Explore simple, accessible and easy to implement Information and Communication Technologies (ICT) solutions such as short message service (SMS), Interactive Voice Response (IVR), radio and television, drones, online marketing, e-extension platforms, social media, and so on.
- Take advantage of current formal and informal relations, structures and social networks, such as cooperatives, producer organizations, leaders of communities and farmers, self-help groups and religious groups. These are essential for ensuring timely and widespread information and advice when mobility-restricting measures are in effect.
- Provide timely training as required for advisory service providers. Improve knowledge and educate agricultural extension functionaries about most important topics such as preventive steps, use of ICT, conflict resolution and effective communication as they cope with the context under high stress.
- Convergence with emergency response personnel at central and state level which includes health departments, civil protection, early warning, and others at the frontline leads to disseminate timely advisory services. Regularly update the government on the field situation and challenges facing by the farmers, and enforce the response in partnership with private sectors and other agencies at the ground level.

Agricultural extension and advisory service provisions to reduce COVID-19 impact:

- Carry out a timely assessment of the impacts of COVID-19 in rural areas and identify the specific challenges and needs of farmers and rural communities to inform governments and allow other allied agencies to respond.

- Provide locally relevant advice and services on access to inputs, market knowledge, and easily implementable ways to store and process, use labour saving practices, collective action to promote smart transportation arrangements, and balance supply and demand, especially for perishable items, to reduce post-harvest losses.These are crucial as the COVID-19 pandemic is affecting the economy in several means, disruptions such as market and input shortages, increased food losses, limited labourand lack of transportation require locally appropriate and innovative solutions.
- Increase knowledge through timely and reliable information on relevant government policies, welfare programs, incentives and other preventive measures such as physical distancing and hygiene, as well as the distribution of masks and sanitary items.
- Facilitate access to local agricultural inputs; encourage seed banks at the community and household level, and other strategies to prevent group interactions. This can be accomplished in partnership with local suppliers of inputs, as they are also struggling to keep their distribution lines open with farmers.
- Promote the balancing of labour and supply demand such as labour banks and logistical support. The take-up of these new services by extension agencies is key since harvesting and other labour-intensive agricultural activities are at risk due to shortages in the workforce due to the restricted mobility of occasional and migrant labourers.
- Facilitate conflict resolution: the crisis puts tremendous stress on the population, while fear of infection will disrupt social relations. Extension workers need to be able to manage intra- and inter-community conflicts and have sufficient soft skills to communicate with populations in distress.
- In order to overcome disrupted formal food supply chains, it is necessary to promote local and home-grown food to ensure household food security and facilitate local value chains, informal markets, ICT based food orders and distributions.

RECOMMENDATIONS FOR MEDIUM TO LONG TERM POST-PANDEMIC RESPONSE (FAO, 2020).

While health emergency and restrictive prevention measures may be relaxed over time, thesocio-economic crisis and food insecurity may become even more acute.

1. Service provision to help increase resilience and rebuild the livelihoods of rural people:

- Facilitate linkages with social protection and insurance schemes, including the promotionof self-help and community-saving groups. Also advice on alternative income-generatingopportunities, as many people may have lost their jobs, income, livelihood assets, or breadwinners.

- Promote locally and homegrown produce including underutilized, neglected and nutritiousvarieties and species, as well as the establishment of shorter value chains and local markets,to contribute to local food security in times of disrupted markets and unstable prices.
- Strengthen the capacity of youth and women on issues related to farming as a businessboth technically and functionally/managerially. As a consequence of the pandemic, manyyoung people and women need to be empowered to lead farming as heads of theirhouseholds.
- Enable access to credit and inputs such as seeds and fertilizers by collaborating with privatesector companies, input suppliers, buyers, and contract farming, by offering flexiblesolutions for producers, such as pre-buying at fixed prices etc.
- Facilitate the rebuilding of social relationships and conflict management, as socio-economicdistress continues. Support to organizational processes of producers and grassroots organizations is key to helping communities become cohesive and resilient.

2. Strengthening the capacities of agricultural extension and advisory services to respond to the post-pandemic crisis:

- ***Establish agricultural extension and advisory services response mechanisms to tackle the urgent matters caused by COVID-19 andpost-pandemic crisis:*** It should strengthen the coordination and joint planning of extension agencies at local and national level, and help adapt extension advisory servicesto new crisis-related policies andgovernmental measures.
- ***Ensure funding of extension agencies for advisory services:***lack of resources will become majorissue than before andtraditional funding sources may be at risk (public funding, donors) as priorities may switchto other sectors like health or formal markets.
- ***Increase efficient use of available resources and look for alternatives:*** collaborating withprivate sector, funding for emergency response and recovery, advocate with thegovernment and donors to show relevance of extension advisory services etc.
- Strengthen infrastructure, institutional set-ups and individual capacity to make use of digital information and services.

CONCLUSION

The COVID-19 and measures taken to control the pandemic arehaving a crippling effect on health and food systemsacross the country. Agricultural extension and advisory services plays a crucial role in attainment of food security in this crisis. It can make significant contributions to minimise the impact of COVID-19 in the followingmain action areas*i.e.* raising awareness about COVID-19 in rural areas, assessing the field situation and advocating for urgent solutions to farmers' needs, ensuring continuous support to rural producers in a situation of physical distancing and building partnerships to overcome market disruptions and ensure supply chainfunctioning

across the country. The strong pluralistic extension networks in the country needs to rethink and refine the advisory services and disseminate the timely information to the rural agrarian communities to attain the food security in the times of unprecedented crisis.

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Closed sub-surface drainage to ameliorate water logged and salinity in a canal command area – A success story

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Summary

Reclamation of saline, saline-alkali and waterlogged soils formed due to the intrusion of flood waters can effectively be done by the closed sub-surface drainage (CSSD) technology. The CSSD technology is the most appropriate under the salinity and water logging conditions to leach out the excess and harmful salts from the crop root zone, providing a better environment to the plants to grow. In south Gujarat, CSSD technology was installed in Patel's farm situated at Virpor and Ghala village, Taluka Choriyasi, District Surat of Gujarat state in the command of Surat branch under UkaiKakrapar (UKC) irrigation project. With successful operation of the system, the water logging problem has reduced and average water table has been lowered from 36.5 to 50.0cm. The soil salinity has been reduced from 6.7 to 3.5dS/m. The sugarcane yield has increased from 58 to 96 t/ha *i.e.* 65.5 % higher than without CSSD technology. The farmers are happy and express the satisfaction over the performance of dual purpose subsurface cum irrigation system.

Irrigation projects play pivotal role in enhancing the crop productivity and bringing prosperity to the area. However, if the created irrigation facility is not properly utilized, then the natural resources *viz.*, soils and crops/vegetation are deteriorated to such an extent that they become unproductive. Though drainage is envisaged in project document of each and every command, seldom it receives due attention after commissioning of the project. The introduction of irrigated agriculture, however, has resulted in the development of the twin problem of water logging and soil salinization. Considerable areas have either gone out of production or are experiencing reduced yield. With the misconception, that the more they irrigate, the more yield they will get, farmers apply huge quantities of canal water. Furthermore, the introduction of canal irrigation not only brings the much needed water, but also imports salts as irrigation water contains considerable amounts of salt. Inmany canal commands, there has been a

rise in the water table and consequent degradation of soils through water logging and secondary salt build-up and the impact of irrigation over many years have caused the ground water table to rise into root zones in these command areas, which led to reduction in crop yields. The time required to appear these problems and their severity vary with soil type, cropping system adopted by the farmers, maintenance of the canals and presence of net work of natural drains in the command areas.

Indiscriminate and excess use of water by farmers and faulty irrigation application system, the worst fears came true in the form of water logging and secondary salinization particularly in low lying areas of Ukai-Kakrapar Command (UKC) on river Tapi in South Gujarat. In UKC area, 15 per cent of land is actually suffering from these problems and another 25 per cent land is critical mainly due to high clay containing soils, adoption of faulty irrigation methods (flooding, field to field etc.) by ignoring the land irrigability classification, inclination towards high water consuming crops like paddy, sugarcane, banana *etc*., by neglecting suggested cropping pattern and heavy rainfall (1400 mm). Under this circumstance, subsurface drainage is considered as a most suitable approach for removal of excess groundwater from the crop root zone system which promotes safe environment for efficient crop growth. Moreover, subsurface drainage has been found to be the only solution for providing land reclamation on a long-term basis when salts are present in the soil and groundwater. The team of scientists designed proper drainage as well as other measures for land development. Development of efficient drainage system and its maintenance, provision of interceptor and collective surface drains, plantation of bio-drainage trees resulted into lowering of water table and farmers are able to cultivate their land. The farmers of UKC have not simply adopted the CSSD in affected area, but they are also doing some modifications in the system, so as to meet their site specific requirement. Several farmers have been benefited with this achievement but Patel's emerged as a leader in adopting the package of technologies for reclaiming barren land due to water logging and salinity, the success story is discussed here.

Farmers details: The closed subsurface drainage has been installed on the fields of Shri MorarbhaiKoyabhai Patel, Head of family, Shri BalvantbhaiMorarbhai Patel and NayanbhaiMorarbhai Patel are the son at Virpor and Ghala village, Taluka Choriyasi, District Surat of Gujarat state in the command of Surat branch under UkaiKakrapar irrigation project with the technical support from Soil and Water Management Research Unit, Navsari Agricultural University, Navsari (Gujarat).

Objective: The basic objective of drainage is to remove excess water from waterlogged fields. Further, it also helps in reducing secondary salinization/ sodicity problems from the field. The other problems related to water logging conditions are poor growth and yield of crops, land workability (preparation) and higher infestation of pest and diseases are the problems due to continuous wet condition *i.e.*, vapsa condition is not

attained. All this aspects have negative impact on crop growth and ultimately reduce yield. Subsurface drainage installation helps in lowering the water table below root zone by draining excess water and also reclaiming the salt affected soils.

GENERAL CHARACTERISTICS AND HISTORY OF FIELDS:

The soils are heavy with more than 48 per cent clay. The soil is moderately alkaline in reaction, high in soil salinity. The soil salinity in most parts of the area is higher than 6.5dS/m at all the depths. On the basis of Electrical Conductivity of saturation extract (ECe) of the soils, most of the area has been identified with salinity problem. The water table fluctuated between the soil surface in the monsoon season and 1.5 m from the ground level in summer season. Rainfall is very high during mid July to August.

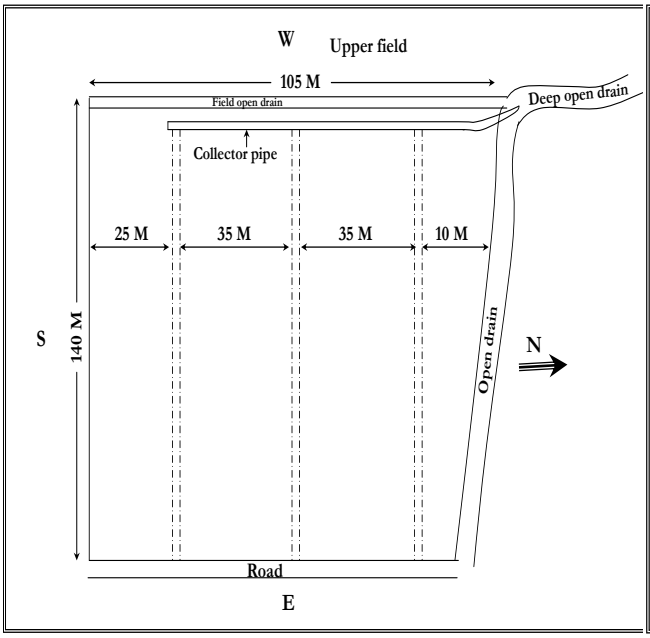
Earlier farmers used to grow cotton and pigeon pea. However, they shifted to sugarcane with the availability of UkaiKakraparirrigation. He has ten acres of fertile soil, recalled the happiness of his elders when canal water was made available to their land.Patel's were very happy to irrigate their field and getting good yield of sugarcane consequently their family was prospering. The number of irrigations varies from 12 to 14 times during the entire crop growth period of sugarcane crop. The canal water has a salinity of 0.3 dS/m, thus an irrigation gift of 1600 to 2000 mm/year added 3.5 to 4.0 t/ha of salts to the soil profile. He was irrigating their field as much as possible but slowly he realized that problem of water logging (with in 1 to 1.5 m bgl) building up in their soil due to low lying topography, over irrigation and low permeability of soil. Moreover, seepage of canal contributed major share of this water and the whole area has became muddy and there was no way to drain out the excess water as collected in the pocket. The natural drains were choked with weeds like *Typha, Lantana* and *Ipomea*. Unable to get the proper yield, he was very worried and realized that over irrigation and unscientific practices have made his land barren. Meantime, the farmers heard about some technology about drainage and consequently they visited the Soil and Water Management Research Unit, NAU, Navsari. They interacted with the scientists and very happy to know about the subsurface drainage technology which can get rid of the water logging as well as salinity and sodicity of their field. As suggested by the scientists, the farmers started on the guidelines for reclamation of their land. With full enthuse and motivation, he helped the scientists in all respects and he was happy that the drain which earlier was choked with weeds was cleared with the use of herbicides as suggested by the scientists. The University recommends subsurface drainage for waterlogged and salt affected soil besides addition of organics (manures and green manure). Farmers themselves did expenditure on the subsurface drainage system. Now, he realized the importance of maintaining the proper drainage in the field.

DRAINAGE TECHNOLOGY TECHNICAL DETAILS

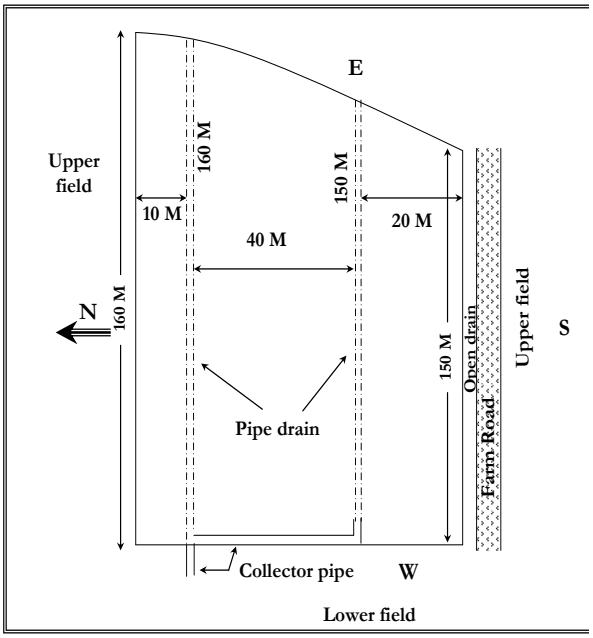
Corrugated PVC pipes with a diameter of 80mmwere used for the field drains and rigid PVC pipes with diameters of 180mm for the collector drains. Subsurface drainage with PVC corrugated pipes were laid at 35 - 40 m between two drains and at an average depth of 1 to 1.5 m.Price of PVC corrugated pipe was around Rs. 85/m. The cost include

excavation trench using JCB, labour cost for laying of pipe corrugated pipe and refilling on trench, cost and laying of PVC pipe as conveyance connecting corrugated pipe to nallas outside field was around Rs. 25,000 to 30,000. Overall, cost of the system is around Rs.40,000 to 55,000/- per ha.

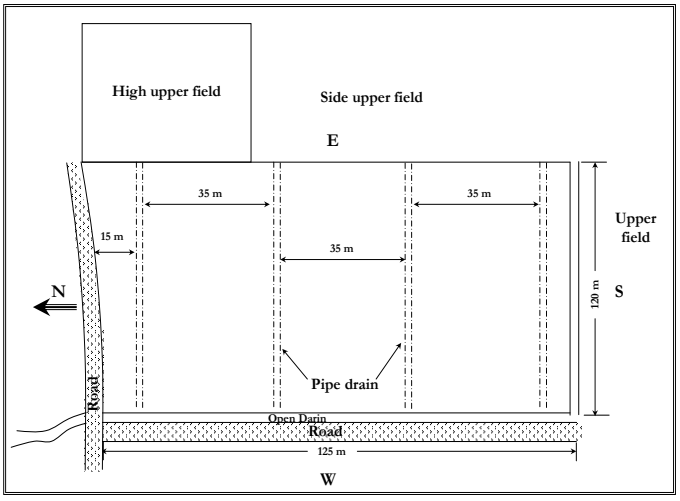
Closed Subsurface Drainage system layout



Farmer's name: MorarbhaiKalidasbhai Patel
Village: Virpor**, Taluka:** Mandvi**& Dist. :** Tapi
Block No. 184, **Area.** 1.47 ha.



Farmer's name: NayanbhaiMorarbhai Patel
Village: Ghala, **Taluka:** Kamrej**& Dist. :** Suarat
Block No. 314**Area.** 2.40 ha.



Farmer's name: BarvantbhaiMorarbhai Patel
Village: Ghala, **Taluka:** Kamrej**&Dist. :**Suarat, **Block No.** 314**Area.** 1.50 ha.

The system works by gravity and drainage water disposed in to stream, which ultimately take it to Tapi river, is 1.2 km away from the farmers fields. At one of the main closer drainage, farmers have made provisions to put surface water into it, in the

event of surface stagnation due to excess rainfall. The collector pipe thereafter is of rigid PVC pipe. Whenever required, fresh water is pumped from the stream/Nala and put into rigid collector through pump stand. The collector line is used as lift irrigation pipeline to irrigate the fields. Thus, farmers are using collector line for surface drainage, subsurface drainage and irrigation. Because of multiple uses of the system they are also taking care of the system.

INCREASED THE SUGARCANE CROP YIELD AND ECONOMICS DUE TO CLOSED SUB-SURFACE DRAINAGE SYSTEM

Sugarcane crop yield from the closed subsurface drainage system were from 87 to 105 ton/ha. Average yields obtained under closed subsurface drainage systems were noticeably significant *i.e.* 96 ton/ha that was 65.5 % higher compared to without installation of CSSD system filed that produced only 58 ton/ha. Subsurface pipe drainage removes excess soil water and salt that keep the soil moisture; along with improvement of soil aeration favours the crop growth. Also, quantifying the influence of this system on the salinity of drainage water indicated that electrical conductivity (EC) and total salt load decreased markedly. From the performance point of view of drainage system operation, crop yields are generally expected to increase with the installation of subsurface drainage system. The results showed direct relationship between improvement of system performance and increasing in sugarcane yield, followed by a rise the economic returns. An economic analysis showed that the cost of installing subsurface drainage systems was readily justified by annual increased sugarcane yield.

Table 1. Impact of CSSD System on sugarcane crop production and economics

Farmers name	**Crop**	**Crop yield (t/ha)**		**increase in yield**	**Cost of cultivation**	**Net income**	**BCR**
		Drainage installation					
		Before	**After**	**%**	**(Rs./ha)**	**(Rs./ha)**	
Morarbhai K. Patel (Head)	**Sugarcane**	62	96	54.8	126000	220800	1.75
Balvantbhai M. Patel (Son)		60	105	75.0	130000	241500	1.86
Nayanbhai M. Patel (Son)		52	87	67.3	125000	200100	1.60
Average		**58**	**96**	**65.5**	**127000**	**220800**	**1.74**

Note : Sugarcane : Rs. 2300/ton (average of three year)

REDUCTION IN GROUND WATER TABLE DUE TO CLOSED SUB-SURFACE DRAINAGE SYSTEM

Generally, the mean water tables became deeper from year to year. The water table range of 35 – 38 cm (average: 36.5 cm) below ground level before CSSD was lowered

and maintained at 47-52 cm (average: 50.0 cm) in the post-drainage situation indicating significant improvement.By improving the soil conditions for water movement and also increasing drain discharges, the performance of deep drainage systems improved. The main causes of the rise in water table are precipitation, excess irrigation, leaching water, seeps from higher land or irrigation canal and ditches and groundwater under artesian pressure that reduced by subsurface close drainage technology by removing excess groundwater from the crop root zone system which promotes safe environment for efficient crop growth that reflect on higher crop yield.

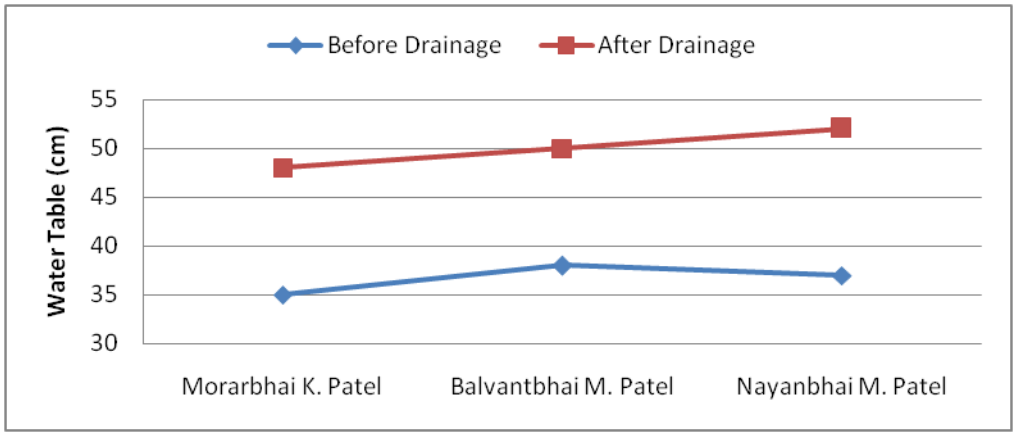


Fig. 1 impact of Closed Sub-Surface Drainage System on ground water table

REDUCTION IN SOIL SALINITY DUE TO CLOSED SUB-SURFACE DRAINAGE SYSTEM

There was considerable reduction in soil salinity. Graph was drawn to observe the changes in ECe before and after the installation of the system (Fig 2). Overall effect was positive and three years after installation, ECe has been lowered. Before the installation of drainage systems, ECe ranged from 6.3 to 7.1 (average: 6.7 dS/m) and after installation of drainage systems, this has observed 3.2 to 3.8 (average: 3.5 dS/m), respectively. The upper layers are reclaimed at a faster rate than the deeper layers. Within three years after installation of drainage systems, sub surface drainage technology can also be effectively used in the saline and sodic soils to remove the salts in huge quantities from the profile in shortest possible time. Establishment of sugarcane crop was good after installation of drains and general yield increase was 55 to 75 %.

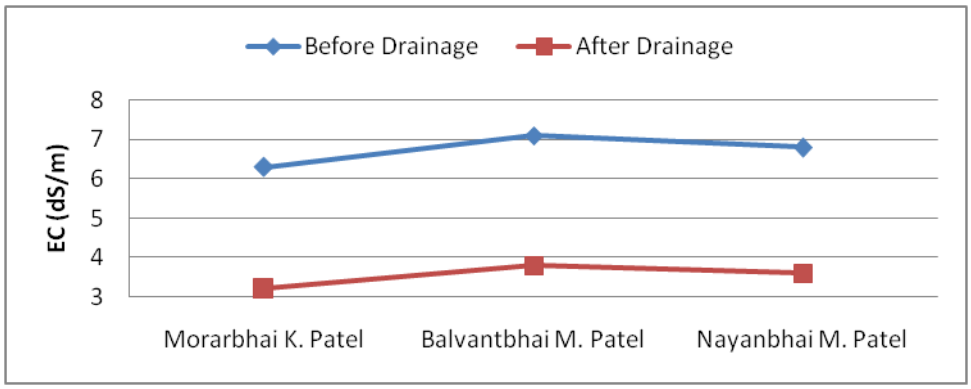


Fig. 2 impact of Closed Sub-Surface Drainage System on soil salinity

CONCLUSION

Adoption of subsurface drainage system was found highly effective in reclamation of water logged and salt affected lands. Water table and ECe of soils were improved by 52.2 and 36.9 per cent, respectively. Ultimately, sugarcane crop yield increased by 65.5 per cent.

ACKNOWLEDGEMENT

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Installation of sub surface drainage

Crop after installation of CSSD

Insecticidal Value of Fungicides- Potential Benefits through Their Performance and Compatibility

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ABSTRACT

In the current scenario of agriculture, none of the crops are free from invasion of insect and diseases or both. As a result, the potential economic losses caused by such ravages are enormous. Hence, majority of farmers relied up on synthetic pesticides and frequently applying pesticides such as insecticides, fungicides and acaricides etc either singly or in combination as tank mixture. This led to tremendous increase in usage of total pesticides and pose severe threat to environment by altering the ecological balance, increase of toxic pesticide residue in food chain and killing non target beneficial natural enemies. Among pesticides, usage of insecticides is more followed by fungicides, herbicides and other agro chemicals. Many fungicides are known to control insect populations when are intended to use against harmful plant pathogens. In addition application of both fungicides and insecticides separately would lead to considerable increase in cost incurred on plant protection activities. Hence, the potential benefits of fungicides exhibit insecticidal activity are to be identified and their compatibility and utilization in pest management programmes have to be adopted to reduce risk on cost of economics in crop cultivation. Other hand, this is an added advantage while targeting insect pests and helps to reduce major environmental problems due to accumulation of toxic pesticide residues in the ecosystem.

Keywords: Compatibility, Insect pest, Pesticide Residue, Tank mixture

INTRODUCTION

In India, many farmers are marginal land holders and doing their Agriculture mostly under rainfed conditions. Monsoon rainwater satisfies the water requirement of many crops. This substantiates their total cost of crop production. Crops raised under different farming conditions affected by many pest and diseases. Among different pests that affect the crop growth and development insects and diseases contributed about more than 60 per cent. In order to manage this, mostly they are not following any scientific plant protection measures. Among agro chemicals used in India, the use of fertilizer followed by insecticides

and fungicides are found to be more. Very often, spraying different agrochemicals is done together by tank mixing, in order to reduce the cost of crop plant protection and to tide over the labour shortage (Schenck and Atlerz, 1962) and also save the time. But scientifically this method is not advisable and unless the compatibility study between two agrochemicals has not been conducted it should not be tank mixed. If so, that may end up with many kinds of phytotoxicity defects. Even though the volume of fungicides sprays on crop plants are more it can also control some selective insect pests. Earlier reports were available on insecticidal value of fungicides. Hence, the role of fungicides in reducing the insect pests is getting importance and become a potential area where in much attentions are to be paid.

PRESENT SCENARIO OF PLANT PROTECTION

In modern agriculture, occurrence of insect and disease pests together in many crops necessitate the demand the simultaneous application of insecticides, fungicides and fertilizers are practiced (Nelson et al., 2016). Due to involvement of pesticide application costs, many farmers perform tank mixing of insecticide with a fungicide to save application cost. This may pose some negative consequences during later stages of crop growth or season. Adding an insecticide to a preventative fungicide may reduce application costs required for a separate application, but onset of insect resistance (Stern et al., 1959; Phillips et al., 1989) and phytotoxicity are is important to maintain the availability of cost-effective insecticides. On the other hand, the inclusion of broad spectrum chemicals in pest management is practiced from long back. But this also should pose positive effect on biological control of insect and disease pests (Martinou et al. 2014 and Mills et al., 2015). Thereby, combined post effects these chemicals on non target organisms have to be critically evaluated for their suitability in IPM.

INSECTICIDAL ACTIVITY OF FUNGICIDES

Fungal pathogens are responsible for several detrimental plant diseases. Fungicides from various chemical groups are often used for suppression of the harmful plant pathogens at different crop stages. Fungicides generally designed for the management of fungi and occasionally display significant level of impact on insect population reduction. Additionally it has to pose minimal toxicity to beneficial insects if they are intended to use for the context of insect pest management.

Table 1. List of some fungicides expressing insecticidal activity

S. No.	Fungicide	Target insect/ mite pest	Action	Reference
1.	Benomyl	Soybean semi looper, *Trichoplusia ni* (Hubner)	Feeding avoidance	Schenck and Adlerz (1962)
		Amblyseius fallacis (Garman)	Reduced feeding	Nakashima and Croft (1974)
		Several phytophagous mites	Feeding deterrence	Delp and Klopping (1968)

S. No.	Fungicide	Target insect/ mite pest	Action	Reference
2.	Triphenyltin hydroxide	Tobacco caterpillar, *Spodoptera litura* Fabricius and rice cutworm, *Agrotis ipsilon* (Hufnagel)	Feeding deterrence	Ascher and Rones (1964)
		Maize cob borer, *Heliothis virescens* (F.)	Insecticidal property	Graves et al. (1965).
		Soybean semi looper, *T. ni*	Reduced pupation	Schenck and Adlerz, (1962)
3.	1-Acetyl-3,-5-diarylpyrazolines	Aphids, *Aphis medicagini* Koch., rice BPH, *Nilaparvata legens* Stal., Cutworm, *Mythima separata* (walk.) and Carmine spider mite, *Tetranychus cinnabarnus* Boisduval	Insecticidal and acaricidal property	(Zhao *et al.,* 2008).
4.	Stem bark of *Zanthoxylum armatum*	Mustard aphid, *Lipaphis erysimi* (Kaltenbach) and *Fusarium oxysporum*	-	(Rakesh Raturi et al., 2014)

Many fungicides exhibit their insecticidal activity through disturbing the neurophysiology, development, longevity, fecundity and sex-ratio of insects and also the essential insect behavioral processes like, mobility, orientation, feeding, host searching, mating and oviposition and of natural enemies (Desneux et al., 2007; Biondi et al., 2012 and Roditakis et al., 2014).

INSECTICIDE AND FUNGICIDE COMPATIBILITY

Nowadays, farmers are widely using several insecticide and fungicide mixtures to manage insect and disease pests howbeit, very limited works have been conducted on their multi activity against different pests and compatibility. Johnson (2015) reported that majority of fungicides at their optimum dosed expressed low acute toxicity to honey bees and also known to enhance the toxicity of insecticides when applied together in as a tank mixture. Majority of fungicides and insecticides are applied during same time on almond and fungicides like iprodione, pyraclostrobin and propiconazole expressed good compatibility with insecticides.

The other possible effect of fungicides is their compatibility with insecticides and safety against beneficial insects and certain entomopathogenic fungi (Schenck and Adlerz, 1962). Insecticides such as pyriproxyfen and spirotetramat had positive compatibility with fungicides like chlorothalonil, copper oxychloride, cyazofamid, fluopicolide + propamocarb hydrochloride (FPH), penconazol, trifloxystrobin and showed great safety on zoophytophagous mirid predatory insect, *Nesidiocoris tenuis* (Ziaei Madbouni et al., 2017).

On the other hand, Samson et al. (2005) proven the safety of *Metarhizium anisopliae* is compatible with insecticides and fungicides. Similarly, while targeting the pest complex in almond gardens of China, the sterol biosynthesis-inhibiting (SBI) fungicide, propiconazole applied with either diflubenzuron or chlorantraniliprole showed good compatibility and less toxicity to grubs and adults of honeybees (Wade et al., 2019).

Table 2. Some examples for insecticide and fungicide compatibility against crop pests

S. No.	Fungicide and Insecticide expressing safety	Target agent	Reference
1.	Chlorantraniliprole (0.03%) and Hexaconazole (0.2%)	Rice leaf folder, *Cnaphalocrocis medinalis* Guenee and sheath blight, *Rhizoctonia solani*	Bhuvaneswari and Krishnam Raju. (2013)
2.	Pymetrozine (0.05%) and Validamycin (0.2%)		
3.	Thiamethoxam with Fludiaxonil and Mefenoxam	Sap feeding insects and *Phytophthora* and *Rhizotonia*	Syngenta Crop protection (2011)
4.	Cartap hydrochloride and Tricyclazole	Rice leaf folder, *C. medinalis* and blast disease, *Pyricularia oryzae*	Bhatnagar (2004)
5.	Indoxacarb and Cartap hydrochloride with Tricyclazole and Iprobenphos	Leaf folder, *C. medinalis*, stem borer, *Scipophaga incertulas* (Walker) and neck blast of rice	Singh *et al*. (2010),
6.	Triazophos (0.02%) along with Carbendazim (0.05%) and Tricyclazole (0.04%)	Leaf folder, *C. medinalis*, white backed plant hoppers, *Sogatella furcifera* (Hovarth) and blast disease	Prajapati *et al.* (2005)

Table 3. Compatibility chart for Important Pesticides

Name of the pesticide	Chlorothalonil	Copper oxychloride	Difenoconazole	Hexaconazole	Iprodione	Mancozeb	Metalaxyl	Metalaxyl + Mancozeb	Acetamiprid	Azadiractin	Cartab hydrochloride	Cypermethrin	Deltamethrin	Fenazaquin	Imidachloprid	Indoxacarb	Lambda-cyhalothrin	Malathion	Profenofos	Spinosad	Thiodicarb
Chlorothalonil	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	N	N	Y	Y	Y	N	Y	N	N
Copper oxychloride	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y
Difenoconazole	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Hexaconazole	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Iprodione	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mancozeb	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
Metalaxyl	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
Metalaxyl + Mancozeb	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
Acetamiprid	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Azadiractin	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cartab hydrochloride	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cypermethrin	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Deltamethrin	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Fenazaquin	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Imidachloprid	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Indoxacarb	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Lambda-cyhalothrin	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Malathion	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Profenofos	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Spinosad	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Thiodicarb	Y	N	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Y- Compatible; N- Incompatible

(Source: Value chain on Flowers for Domestic and Export Markets, Tamil Nadu Agricultural University, Coimbatore)

CONCLUSION

In viewing the aforeseen potential effects of fungicides possessing insecticidal properties, further scientific studies are required in order to exploit their multi potential role insect pest suppression of various categories without causing any alterations in the balance in ecology and physiology of pests. While, both insecticides and fungicides are applied in combined manner, selection of right compatible compounds for tank-mixes is to be studied scientifically. When these got success, the indirect effect of potential fungicides in reducing the insect pest populations can be considered in insect pest management during the insecticide spray.

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