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Growing seed

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ROLE OF WOMEN IN AGRICULTURE

Article Id: AL202106

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Now-a-days, developing awareness and dedication of the global community to accomplish more sustainable and broadened agrarian growth by focusing on the consequences associated with gender through national, regional and universal initiatives and partnerships. An urgent requirement of reorienting the agricultural research agenda is emerging out to conquer the existing gaps and also to face the constraints of sustainable development and livelihood of resource-poor smallholders, more specifically women farmers. Nevertheless, in this exigency, in-depth evaluation of challenges accompanied with proper activities for solutions is demanded. Convenient technologies should be transmitted to farm women for increasing agricultural productivity and empowerment. Additionally, diverse practical steps should be engaged to support rural women so that they can also be considered as 'productive resources' and citizens who have an equal claim with men on the protections, opportunities and services provided by the governments as well as the international community. There are several reasons behind the underperformance of agricultural sector in many developing countries, and among all of these causes, the dearth of resources and opportunities granted for women is very much significant which is required by them for the most productive utilization of their time. Although being farmers, labourers as well as entrepreneurs, women face acute challenges almost everywhere than men in accessing productive resources, markets and services. This non-sense 'gender gap' is hindering their ability, capacity, productivity and reducing their valuable contributions to the agrarian section and also to the broad-based achievement of economic and social development goals. Mitigation of this gap can help to produce considerable advantages for our nation by improving agricultural productivity, reducing poverty, hunger and malnutrition, including the promotion of financial growth. Agricultural policy-makers, donors and development practitioners demand information and analysis for contemplating the diversification of the benefactions of women along with the constraints confronted by them in

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order to make gender-aware decisions about this sector and also have commitments to guarantee that women are efficient to participate fully in and benefit from the process of agricultural development. Notwithstanding, the advancement of gender equality facilitates the diminution of extravagant poverty and hunger, and it would be beneficial for better agricultural development.

Work participation scenario

- According to the Census, 2011 it was reported that out of total female workers, 55% were agricultural labourers and 24% were cultivators.
- Only 12.8% of the operational holdings were owned by women.
- 25.7% of the marginal and small operational holdings are concentrated by women.
- Women farmers represent more than a quarter of the world's population.
- Women comprise, on an average, 43% of the agricultural workforce in developing countries, ranging from 20% in Latin America to 50% in Eastern Asia and Sub-Saharan Africa.
- Worldwide, about 42% of women workers were engaged in agriculture in 2010, down from 53.5% in 1980. In developing countries, agriculture supported about 52.7% of women workers in 2010.
- In South Asia and India, over 60% of women workers are engaged in agriculture (FAO, 2010-11).
- As per 2011 Census data, no improvement was noticed in the female work participation rate (WPR), which stood at 25.5%, while the male WPR improved to 53.21%.
- The share of women in total agricultural workers was reported 39% in 2001, but it declined to about 37% in the year 2011.

Women in agriculture and allied sectors

The operations regarding agriculture and its allied sectors carried out by women are discussed in details as follows:

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1. Agriculture

More specifically, rural women are employed in many agrarian activities in three major ways depending upon the socio-economic condition of their family as well as the regional issues. They are engaged as:

- Paid or unpaid labourers on other farms and agricultural enterprises
- Farmers on their own account, as unpaid workers on family farms
- Managers of certain aspects of agricultural production by means of labour supervision and participation in post-harvest operations also.

The types of numerous labour-intensive agricultural activities taken up by rural women include:

- Sowing
- Nursery management
- Transplanting
- Hoeing
- Grass cutting and weeding
- Picking, cotton stick collection and separation of seeds from fibre
- Irrigation
- Fertilizer application
- Plant protection
- Harvesting, winnowing, storing etc.
- Crop and livestock production at subsistence and commercial levels
- Produce food and cash crops and manage mixed agricultural operations often involving crops, livestock and fish farming.

2. Livestock

Livestock is an elementary livelihood activity for fulfilling household food demands as well as supplements farm incomes also, and it is documented that rural women can earn additional income from the sale of milk and animals. An estimated two-thirds of poor livestock keepers, totalling approximately 400 million people, are women (Thornton *et al*., 2002). It is evident that predominantly women play a dominant role in livestock production and perform management activities such as

- Cleaning of animal and sheds

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- Watering of cattle
- Milking the animals
- Milk processing, preparation of ghee, etc.
- Fodder collection
- Preparing dung cakes
- Collection farmyard manure

3. Poultry

Poultry farming is one of the major sources of the rural economy, and the rate of women participation at the household level is central in the poultry industry.

4. Fisheries and aquaculture

Information provided to FAO from 86 countries indicated that in 2008, 5.4 million women worked as fishers and fish farmers in the primary sector that represented 12% of the total.

They are more commonly occupied in

- Subsistence and commercial fishing from small boats and canoes in coastal or inland waters.
- Processing and marketing stages, in both artisanal and industrial fisheries
- Fish processing as entrepreneurs and provide labour before, during and after the catch

5. Forestry

Women contribute to both the formal and informal forestry sectors in many remarkable ways.

They play active roles in

- Agroforestry
- Watershed management
- Tree improvement, and
- Forest protection and conservation
- Maintenance of nurseries to plantations, and from logging to wood processing

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Feminisation of agriculture

Economic Survey conducted during 2017-18 revealed that with the rising migration of rural people to urban areas, the feminisation of agricultural sector started to flourish with the escalating number of women engaged in numerous responsibilities such as cultivators, entrepreneurs, and labourers also. Worldwide, empirical evidence showed that women play a conclusive function in ensuring food security and conserving local agro-biodiversity. Rural women are trustworthy for integrated management and utilization of diversified natural resources for meeting domiciliary requirements on a regular basis which impel women peasants to have differential and amplified access to important assets *viz.* land, water, seeds, credit, markets, technology and training warranting critical analysis in the context of our country. Moreover, the authorization of women cultivators can be the basic key to augment agricultural productivity with a paramount role at all grounds from production, pre-harvest, post-harvest processing, packaging to marketing and other sectors of the agricultural value chain. It is quite commanding to accept an 'inclusive transformative agricultural policy' aiming at gender-specific interventions to raise production levels of small and marginal landholdings, integrate women as active agents in rural transformation, and engage men and women in extension services with gender expertise.

Conclusion

Women have been cooperating gigantically in favour of all-inclusive agricultural growth and development through the means of their engagement in crop production, horticulture, animal husbandry, poultry, aquaculture, natural resource management and so on. Although the proportion of women workers in agriculture has declined, yet they constitute a significant workforce and economically active population in agriculture throughout the globe. Their involvement differs across the regions, socio-cultural and agro-production systems also. Moreover, the persisting gender gap in access to and control of resources remains an important concern which has not only kept women in a vicious circle of low productivity but also has thrown up questions about inclusive and sustainable growth of this sector. Therefore, the need of the hour is to bridge the gender gap and empower women with new knowledge and technology, and it would be quite challenging, particularly in the context of socio-economic and climate-related changes.

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REVIEW ON IMPACT OF CLIMATE CHANGE ON PLANT DISEASES

Article Id: AL202107

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Climate change refers to any change in climate over periods time, whether due to natural unpredictability or because of human interferer (IPCC, 2007). Climate encompasses the long-run pattern of numerous meteorological phenomenon (e.g. temperature, humidity, atmospheric pressure, wind, rainfall, sunshine etc.) in a given location or larger region. Worldwide losses due to diseases range from 9 to 16% in rice, wheat, maize, barley, potato, cotton, soybean and coffee. Plant diseases was respond to climate change, through a number of interactions, take place among the host, pathogen and potential vectors. Effects of climate change on plant diseases, crop yield as well as on pathogen activities. As results, currently, more than 800 million people do not have ample food and at least 14% of global food production is declined due to plant diseases (Agrios, 2005). Weather parameters like temperature, an elevated level of CO_2 and ozone, precipitation and humidity play a dynamic role in diseases development. Changes in temperature and precipitation have influence disease epidemiology.

Climate change refers to a change of climate that is attributed directly or indirectly by human bustle that alters the composition of the global atmosphere, and climate variability observed over comparable periods. It refers to any change in climate over time, whether due to natural variability or because of human interferer (IPCC, 2007). Climate encompasses the long-run pattern of numerous meteorological phenomenon(e.g. Temperature, humidity, atmospheric pressure, wind, rainfall, sunshine etc.) in a given location or larger region. Plant diseases significantly reduce the production of more than 25 crops that stand between the rapidly expanding world population and starvation. Worldwide losses from diseases range from 9 to 16% in rice, wheat, maize, barley, potato, cotton, soybean and coffee. In the USA alone, fungicides worth over the US $11.2 billion for control diseases. (Agrios, 2005). Plant diseases was respond to climate change, through a number of interactions, take place among host, pathogen, potential vectors. Plant diseases continue to cause serious problems in global

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food production. Currently, more than 800 million people do not have adequate food and at least 14% of global food production was decline due to plant diseases (Agrios, 2005).

Effects of Climate Changes on Plant Diseases

Elevated CO_2adversely affect the physiology of host and pathogen interaction, increase in the canopy have a positive correlation and increase the density of foliar diseases, moisture stress increase dry root rot disease incidence and severity in case of anthracnose.

Host susceptibility has a positive correlation with temperature and moisture *i.e.* impact of temperature on stem rust of wheat was observed. In wheat varieties, resistant was observed at 15°C, and it was fully susceptible at 20^{0}C. Due to high temperature, the rapid development of pathogens was observed i.e., rust on groundnut (Mayee, 1996), Pathogens on chickpea, UG– 99 stem rust of wheat and Rhizoctonia in chickpea as well as Phytophthora on Pigeonpea and Soyabean. More rapid vector development like a vector of viral diseases of rice and vector of citrus tristeza virus was also the effect of temperature fluctuation.

According to Scherm and Coakley, 2003 fluctuation in temperature and humidity also increased over-summering and overwintering of pathogen as well as a vector like Barley Yellow dwarf, Oospore of sunflower downy mildew, Chlamydospore of pigeonpea wilt and Charcoal rot of sorghum.

Effects of Climate Changeon Crop yield

Table-1: Temperature Effects on Crop Yield of Several Major Crops

Crop	T_{opt} ^{O}C	T_{max} ^{O}C	Yield at T_{opt}, t/ha	Yield at 28 ^{O}C, t/ha	Yield at 37°C, t/ha	% Decrease in yield
Rice	25	36	7.55	6.31	2.93	54
Soybean	28	39	3.41	3.41	3.06	10
Dry bean	22	32	2.87	1.39	0.00	100
Peanut	25	40	3.38	3.22	2.58	20
Grain Sorghum	26	35	12.24	11.75	6.95	41

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Rao, 2009 at Hyderabad reported that 100 per cent yield losses observed due to temperature fluctuation in dry bean crop followed by Rice (54%) and grain sorghum (41%).

Effects of Climate Change on Pathogen

Pangga *et al.*, 2004 studied the relative importance of canopy size and induced resistance *to Colletotrichum gloeosporioides* at atmospheric CO_2 concentrations of 350 and 700 ppm on Susceptible *Stylosanthes scabra* in a controlled environment facility in the field and reported that up to twice as many lesions per plant were produced in the high CO_2 plants, because the enlarged canopy trapped many more pathogen spores. Lake and Wade (2009) deliberate the interactions between *Erysiphe cichoracearum* and *Arabidopsis thaliana* under elevated levels of CO_2 and stated that the number of established colonies on mature leaves increased significantly.

The effects of carbon dioxide (CO_2) and ozone (O_3) on three soybean diseases (downy mildew, Septoria and sudden death syndrome) in the field condition have a correlation that elevated CO_2 reduced downy mildew disease severity. However, increased brown spot severity and without effect in sudden death syndrome (Eastburn*et al.*, 2010).

Shin and Yun (2010) also studied the effects of elevated CO_2 and temperature on the incidence of four major chilli pepper diseases *Anthracnose*, *Phytophthora* blight and two bacterial diseases and concluded that elevated CO_2 and temperature have a positive correlation with bacterial diseases that significantly increased the incidence of two bacterial diseases where on other hand *Anthracnose* decreased and *Phytophthora* blight slightly increased.

According to Woods *et al.* 2003, In British Columbia, red band needle blight is causing unprecedented mortality in lodgepole pine plantations and mature stands. The disease outbreak is driven by increases in summer precipitation that are beyond the range of previously recorded weather patterns. Snowmelt exposes shallow fine roots to colder temperatures and results in spring freeze injury that is killing millions of yellow-cedar in Alaska (Hennon and D'Amore 2006, Hennon and Shaw 1997).

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Conclusion

- Now a day climates change is no more myth.
- If changes in atmospheric composition and global climate continue in the future as forecast, there will be the relocation of crops, and their diseases and influences will be felt in economic terms from crop loss.
- Changes in the level of CO_2 and O_3concentration will influence disease by modifying host physiology and resistance.
- Changes in temperature and precipitation will influence disease epidemiology.
- Survival, longevity and aggressiveness are increased with the passage of time due to change in the climatic parameter.

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NON-TIMBER FOREST PRODUCTS (NTFPS) FOR SUSTAINING LIVELIHOOD IN NORTH EAST OF INDIA

Article Id: AL202108

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The North-East part of India is a rich source of natural resources. The North-Eastern region of the country comprising eight states, namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura is endowed with rich forest resources. Of the total forest area of around 68 million hectares in India, the North-Eastern states account for over 17 million hectares, roughly one-fourth of the forest area of the country. All the states of North-East India, with the exception of Assam, have 50–80 % of their area under forests. High temperatures, combined with heavy to very heavy rains, have stimulated the growth of forests at lower levels (Dikshit *et al.* 2013). The region which constitutes only 7.98 per cent of the geographical area of the country, accounts for nearly one-fourth of its forest cover. According to data made available by the India State of Forest Report 2015 the total forest cover of the region is 171,964 sq.km, which is 65.59% of its geographical area in comparison to the national forest cover of 21.34%.

Non-timber forest products (NTFPs) are any product or service other than timber that is produced in forests. They include fruits and nuts, medicinal plants, resins, essences and a range of barks and fibres such as bamboo, rattans, and a host of other palms and grasses. Non-timber forest products (NTFPs) are goods of biological origin other than timber from natural, modified or managed forested landscapes. The NTFPs can also be referred to like all the resources or products that may be extracted from the forest ecosystem and are utilised within the household or are marketed or have social, cultural or religious significance. Globally, more than a billion people depend directly on forests for their livelihoods and the remaining six billion of us depend on forests for a variety of economic, social and environmental benefits (Pandey *et al*. 2016). Out of which NTFPs contribution is significant in providing adequate food, fuel, feed, health and fibre for growing populations. The importance of NTFPs in rural livelihoods in developing countries has become widely

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acknowledged. In India, NTFPs contribute an income equivalent to US$ 2.7 billion per year and absorb 55% of the total employment in the forestry sector. Moreover, 50% of forest revenues and 70% of forest-based export income come from such resources(Shiva and Verma, 2002; Chauhan *et al*., 2008).

Importance of Non-Timber Forest Products (NTFPs) in NER

NTFPs provide green social security to billions of people in the form of food supplements, traditional medicines, fuel and fodder, low-cost building materials and source of employment and income generation. NTFPs are a part of household subsistence strategies, providing macronutrients, carbohydrates, fats and proteins, or other essential micronutrients such as various minerals. NTFPs are used for feeding livestock. The NTFPs such as grasses and leaves are collected by rural communities to feed or house livestock. NTFPs, including medicinal plants, remained as an important source or raw material for traditional systems of medicines like Ayurveda, Chinese, Unani, Siddha, Tibetan and others across the globe. NTFPs are associated with the socio-economic and cultural life of forest-dependent communities inhabiting in wide ecological and geo-climatic conditions in different concentrations throughout the country. The NTFPs also serve as a vital livelihood safety net in times of hardship. As per Government of India report, at least 35 million man-days of employment were generated in the NTFPs trading, which includes collection and processing of economically valuable NTFPs species (Pandey *et al.*, 2016).

As North East states comprises mostly hilly areas. The most local forest fringe people depend on forest products for sustaining their livelihood. Traditionally all types of forest products are sold in all the local market of Eorth Eastern states.

Some local market where forest products are sold in Jampui, Twidu, Kanchanpur, Karbook (Tripura), Pasighat, Naharlagan, Ziro, Mebo, Tawang (Arunachal Pradesh), Aizawl, Champai (Mizoram), Dimapur, Kohima(Nagaland), Karbi Along, Tezpur, Jorhat, Dhemaji, Silapathar (Assam), Imphal, Moirang, Bishnupur (Manipur), Lalbazar(Gangtok), Pakyong(Sikkim), Shillong, Tura (Meghalaya) etc. The minor forest products are sold by local people who are a major source of their income generation. For sustaining the livelihood of the North East people, the importance of non-timber forest product is much more.

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Non-Timber Forest Products (NTFPS) of North East

Bamboo and Cane:

Bamboo is called green gold, in North East India bamboos are grown in the maximum amount. Bamboo based products are counted for high demand in the market. Bamboo shoots found in evergreen, and deciduous forests in North East is considered one of the delicious and nutritious food. Besides, it is consumed as curry, but it is also used for making pickle in Arunachal Pradesh, Tripura, Mizoram, Assam. Bamboo based handicrafts made in Tripura is one of the traditions of the state. The artisans of North Eastern states are making different bamboo-based jewellery, furniture, baskets, decorative home items, shiny mats. Recently bamboo-based water bottle is one of the value-added product which falls under highly attractive items. The important economic bamboo species which are grown in North East are *Bambusa tulda, Bambusa balcooa, Dendrocalamus longispathus, Bambusa pallida, Schizostachyum dullooa, Bambusa polymorpha, Melocana baccifera, Dendrocalamus strictus, Dendrocalamus hamiltonii, Thyrsostachys oliveri* etc.

Canes widely found in Mizoram, Khasi hills of Meghalaya, Manipur, Assam and Tripura. Different household essential products are made from cane which influences the economic condition in the North East region. The leaves of Calamus arboresence are used for roof thatching, stem of Calamus gracilis, Calamus latifolius and Calamus tenuis are used for making handicrafts, furniture and various household items. The cane industries have *a* tremendous role in income generation and producing quality products.

NTFPs as Vegetables:

The forest-based vegetables are contributing major food and nutritional security to the region. In every state of North East, the forest-based vegetables are commonly sold in the market apart from agriculture produced vegetable. Under forest-based vegetable Yongchak (*Parkiarox burghii*) is one of the vegetable tree crop mostly grown in North East. The pods of the tree are used widely for making traditional food in Manipur, Mizoram and Tripura. The plantation of this tree species leads to produce significant income generation to the growers.

Besides pod of Sajna (*Moringa oleifera*) are widely consumed as a vegetable in North east. The fruits of *Solanum indicum*, leaves of *Eryngium foetidum*, bulbs of *Allium hookeri*

are sold in local markets of North Eastern region. The fern *Diplazium esculentum* is one of the popular green vegetable which is mostly available in forest region. The leaves and barks of *Cinnamomum tamala, Cinnamomum cassia* are very commonly used as spice and condiments. The rhizomes of *Curcuma angustifolia, Curcuma zedoaria*and the capsules of *Amomum subulatum* are also used for many traditional foods of North East. The leaves of climber *Paederiafoetida*are also common green leafy vegetable with medicinal properties. The inflorescence of *Musa paradisiacal,* leaves and fruits of *Piper hamiltonii, Piper pedicellatum* are also consumes as vegetable in Arunachal Pradesh, Meghalaya. Presently agroforestry system has been followed for cultivating vegetables in interspacing of forest tree species like teak plantation, sal plantation. Tuber of *Dioscorea* sp. also consumes some parts of Assam as NTFP vegetable.

Fruit Yielding NTFPs:

Various fruit trees are grown in a forest where fruits are collected and consumes. Among fruit trees Jamun (*Syzygium cumini*), Aonla (*Emblica officinalis*), *Terminalia cattapa, Terminalia bellirica, Anacardium occidentale, Eleocarpus floribundas, Tamarindus indica, Spondias pinnata, Aegle mermelos, Artocarpus heterophyllus, Dillenia indica, Baccaurea ramiflora, Zyzyphus mauritiana* etc. are grown widely in the forest of North East. The different species of Citrus are grown in forests are also collected. Assam lemon (*Citrus aurantifolia)* is a common fruit tree in the north east. Apart from horticultural fruit trees, the forest-based fruit trees which are grown as intercrop in forest land has also paved the way for generating income during fruiting season.

The rich biodiversity of the region makes a suitable condition for the birds to disburse the seeds of fruit trees to the different location of forests. Through Joint forest management committee, nursery fruit plants are also provided to the local people for the planting of economic fruit trees. During bearing season, the fruits are also eaten by the wildlife, birds which are maintained forest ecosystem.

NTFPs of Medicinal and Aromatic Value:

In the North East region of India, there are so many communities are residing. For all the states of North East, every community is practising ethnobotany based traditional medicine system. Several medicinal plants are collects from forests of the region. Due to high

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biodiversity and fewer destruction forests, medicinal plants are grown naturally in this region. Even still some hilly region, local peoples are preferred for curing the disease through ayurvedic.

Some of common medicinal plants are found in forests of North East are *Costus speciosus, Withania somnifera, Rauwolfia serpentine, Centella asiatica, Andrographis paniculata, Tinospora cordifolia, Asparagus racemosus, Cissus quandrangularis, Hyptis suaveolens, Azadirachta indica, Vitex negundo, Acorus calamus, Bacopa monnieri, Calotropis gigantean, Chlorophytum tuberosum, Datura stramonium, Curcuma longa* etc. which are used abundantly for curing of diseases.

Some aromatic crops are also grown luxuriously in the interspace of forests. Local people are also surviving by growing and selling of aromatic crops. Citronella grass (*Cymbopogonwinterianus*) and Lemongrass (*Cymbopogon flexuosus*) are grown widely in Assam. The aromatic oil has great demand in perfume industry. Like wise Sugandhimantri (*Homalomena aromatica*) rhizome has high valued aromatic oil. In Manipur, Assam, Tripura local peoples are selling the rhizome of Sugandhimantri, which fetches high market price.

Miscellaneous Forest Products:

Broom grass (*Thysanolaena maxima)*is popular in the North East. It comes under one of the economical non-timber forest product. Cultivation of Cash crops like *Piper betle* and *Areca catechu*are commonly cultivated in Khasi hills of Meghalaya. The leaves*Phryniumcapitatum*is high valued item commonly used in Khasi hills and in Mizoram, as packaging item. The leaves retain the freshness of food items for a longer period. TheAgar (*Aquilaria malaccensis)* plant is grown widely in Assam and Tripura. The agarwood oil has high aromatic value—annatto *(Bixa orellana)* is grown well in the North-East part of India. Seeds yield an edible dye, which is used for colouring butter, ghee, cheese, chocolate, hair oil etc. Simul tree (*Bombax ceiba*) is also grown in Tripura, Assam, Arunachal Pradesh. The floss used as a pillow and the tender leaves used as fodder. The maximum number of different species of orchid is found in North East. The forest of the region is the natural habitat of orchid. In Sikkim, Arunachal Pradesh, Assam, Manipur the different species viz. *Vanda, Dendrobium, Oncidium, Paphiopedilum, Catteliya* are grown. Different types of Palm species are grown in North East. Fishtail palm (*Wadyetia bifurcate*), Fishtail palm (*Caryota urens*), Royal palm (*Roystonea regia*), *Livistonia chinensis* are very common. The leaves of

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the palm are used for thatching purpose. The palms also have ornamental value. The subabul (*Leucaena leucocephala*) is also grown some parts of Assam, Arunachal Pradesh as a fodder crop. *Imperata cylindrical*, leaves and young shoots of *Mikania micrantha*, *Blumea lanceolaria*, *Bidens pilosa*, stem of *Musa balbisiana*are harvested for fodder in Mizoram. In Champai district of Mizoram leaves of *Acacia pennata* are used for masticators purpose. *Phyl anthus emblica*, *Garcinia lanceifolia*, *Callaria brachiate*, *Artocarpus lakoocha* and *Artocarpus heterophyllus* are the fruits harvested from the plantation site in Mizoram. The barks of *Litsea glutinosa* is widely used in preparing incense stick. Incense stick industry is also emerging as large scale in Tripura and Assam.

Conclusion

The north-East part of India is mostly covered by forest. The different forest fringe communities are directly or indirectly depends on forest-based products. Forests of North-eastern region include deciduous, evergreen, moist forest which makes a favourable condition for high biodiversity and natural regeneration of many forest tree species. Economic forest products are growing luxuriously with less destruction. Therefore it is also needed for more scientific collection and harvesting of non-timber forest products. By adopting "Van Dhan Yojana" various forest products are come out successfully from the North East. Recently bamboo made water bottle already draw the attention globally. Even bamboo made various Jewellery, Furniture, Baskets already have high demand in the global market. Apart from that different species of medicinal plants are also found in North East. It is also observed that the income source of the local people of every state of this region, NTFPs plays a vital role. In the months of April-September, the bamboo shoots are collected and make value-added pickle form. The bamboo poles are an integral part of house construction and fencing. The local vegetable is also shared major diet in forest fringe region. It also needed more improvement of livelihood of local people by using scientific techniques of the utilisation of non-timber forest products. Indeed the Research and Training are frequently carried out in Rain Forest Research Institute, Jorhat, Assam and Forest Research Centre for Livelihood Extension, Agartala, Tripura in this region for improving forest-based livelihood by developing improve Bamboo propagation technique, Bamboo nursery, Scientific Sugandhimantri (*Homalomen aaromatica*) cultivation, Cultivation of Broom grass (*Thysanolaena maxima)*, Training on Bamboo handicrafts, Jewellery, Lac cultivation, Beekeeping etc.

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The entire region of North East will be more progress for providing better livelihood by improving income status through green skill development in Non-Timber Forest Products.

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INTEGRATED SOIL FERTILITY MANAGEMENT

Article Id: AL202109

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Soil is one of the most complex biological materials on our planet.Decline in the fertility status of the soil is a major concern in carrying out sustainable agriculture. The increased population has led to the introduction of high yielding varieties of seeds, pesticides and intensive excess of chemical fertilizers, extensive tillage. India is highly affected by land degradation. Land degradation is a serious problem in rain-fed areas. Integrated Soil Fertility Management (ISFM) has to be adopted for the recovery of soil health. The involvement of both chemical fertilizers and organic matter along with the practices of crop rotation and legumes as inter-crops can lead to improvised soil health (Srinivasarao *et al.* 2012; Kumar 2017).

Status of Indian Soil

In India, out of a total of 328.7 million hectares, 142 million hectares are net cultivated area. Out of this 40%, i.e. 57 million hectares are irrigated and rest 60% i.e. 85 million hectares are rain-fed. Out of 328.7 million hectares, about 120.4 million hectares suffer from land degradation, viz., water and wind erosion, waterlogging, soil alkalinity/sodicity, soil acidity, soil salinity and mining and industrial waste. Greater mining of nutrients and intensive agriculture has led to depleting the soil fertility and deficiencies of secondary and micronutrients, depleting water table level and its quality.

Causes and Management of Soil Degradation

Overgrazing, overexploitation of vegetation for domestic purpose, flawed use of land, large scale irrigation canals, deforestation and removal of natural vegetation, agriculture-related activities led to various soil problems like drought, erosion, salinization, flooding and waterlogging. These processes reduced agricultural productivity leading to social insecurity.

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Due to the emission of greenhouse gases causes global warming is a major cause of soil degradation.

1. Soil Erosion

It is the most common and major factor responsible for the degradation of natural resources. Soil erosion remains the most prevalent problem since ancient times. Soil degradation is through the loss of topsoil, which leads to low production and unstable crop yields in rain-fed, semi-arid to sub-humid, sub-tropics of India (Vittal et al. 1990). Wind causes erosion in the arid and semi-arid regions of India, which includes Gujarat and Punjab, Rajasthan, Haryana.

2. Slaking and Dispersion

It leads to the mechanisms of degradation and soil structural collapse (Dhruvanarayana and Babu 1983). Slaking happens when the breakdown of aggregates into smaller aggregates or single particles occurs. Addition of organic matter helps in the reduction of slaking by a reduction in the rate of aggregate wetting and strongly binding of the soil particles together. Separation of clay particles from the aggregates when the soil is wet is called dispersion. Usually, lime is used to avoid the problem of dispersion (Moody and Cong 2008).

3. Salinization and Alkalization

Net irrigated area in India is increased from 22 M ha in 1950 to about more than 68.2 M ha in 2016. This expansion helped to achieve targets of higher production, but it made the level of groundwater level. It leads to deterioration of soil through the accumulation of salts (Abrol and Bhumbla 1971).

4. Acidity

About 6.98 M ha area is affected by acid soils, which is about 9.4% of the total geographic area. Acid soils develop in humid and per humid areas. There are various problems associated with physical and chemical properties that arise due to acidic soils. Liming followed by light irrigation is the most effective technique to help in achieving improved biological and chemical properties of acid soils (Maji *et al.* 2008).

5. Nutrient Imbalance

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To achieve high crop yields, nutrient loss happens in various forms, viz. N_2O, NO, NH_3, and N_2.The usage of fertilizers is increased drastically during the green revolution era in agriculturally developed states like Punjab and Haryana. Poor soil health has been studied in high intensive cultivated areas of rice-wheat cropping system in Indo-Gangetic Plains.N imbalance, and N losses can be improvised by the incorporation of both fertilizers and organic manures without sacrificing the crop yield (Aulakh 2011).

6. Soil Sealing and Capping

Extractive mining activities, conversion of forest to agro-industrial land, as well as the extensive horizontal expansion of cities have been resulting in the soil sealing and capping. Waste and unproductive soils would be used for the establishment of new cities and industries. Artificial, impenetrable surfaces interfere with the essential environmental, economic and social functions performed by soil (Sutton et al. 2009).

Programmes on Soil Management

FAO and its members initiated the Global Soil Partnership (GSP) to improve governance of the soil resources for a food-secure world. Scientific techniques in agriculture for tillage, crop rotation and fertilizer application have to be adopted so that soil fertility, structure and carbon sequestration can be maintained. Use of latest technologies with Geographical Information System (GIS) and remote sensing a global/national soil map can be created to represent different soil types. GIS is used to display, analyze and collect soil data and processes so that different types of soils can be identified (Patel 2016). For the betterment of farmers' knowledge on soil and soil management practices, soil health cards Program was developed in 2006.

Conclusion

Soil health has been identified as a major concern all over the world. Governments have initiated certain programs for the benefits of farmers. Scientists are trying to use available techniques and tools to improve soil health as well as reclaim the lost land. Thus, integrated soil fertility management will enhance our land fertility, productivity and yield, which will be helpful in pulling our population out of poverty and distress.

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HOST PLANT RESISTANCE FOR RICE INSECT PESTS

Article Id: AL202110

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Rice is known as one of the most popularly grown cereal crops in terms of cultivated land and its vast consumption. It is a significant staple food for more than 3.5 billion people all over the world. Like all other field crops, rice is also affected by several insect pests. On a global scale, crop productivity of approximately 14% is misplaced by insect pests (Kebede, 2020). Different type of pests attacks in rice like from borer to sucking pest. So, it is challenging to control all kinds of pests at a time by adopting single management tools. Moreover, excessive application of insecticides causes huge economic imbalance and makes the environment polluted also.

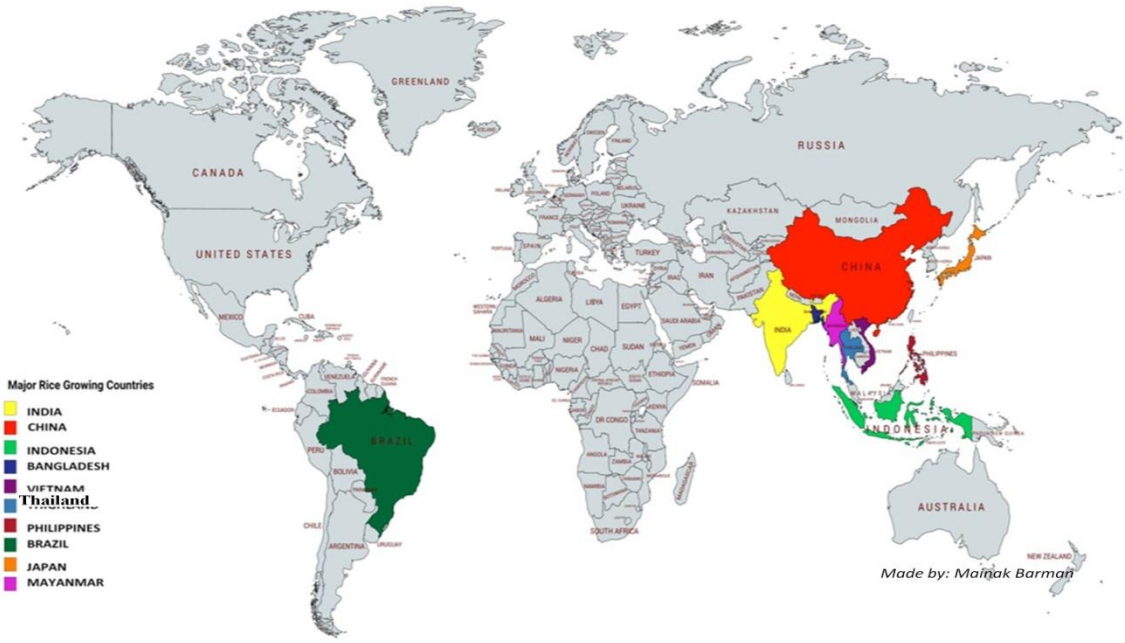

Fig1. Major ten rice-growing countries in the world (Data source: FAOSTAT 2020)

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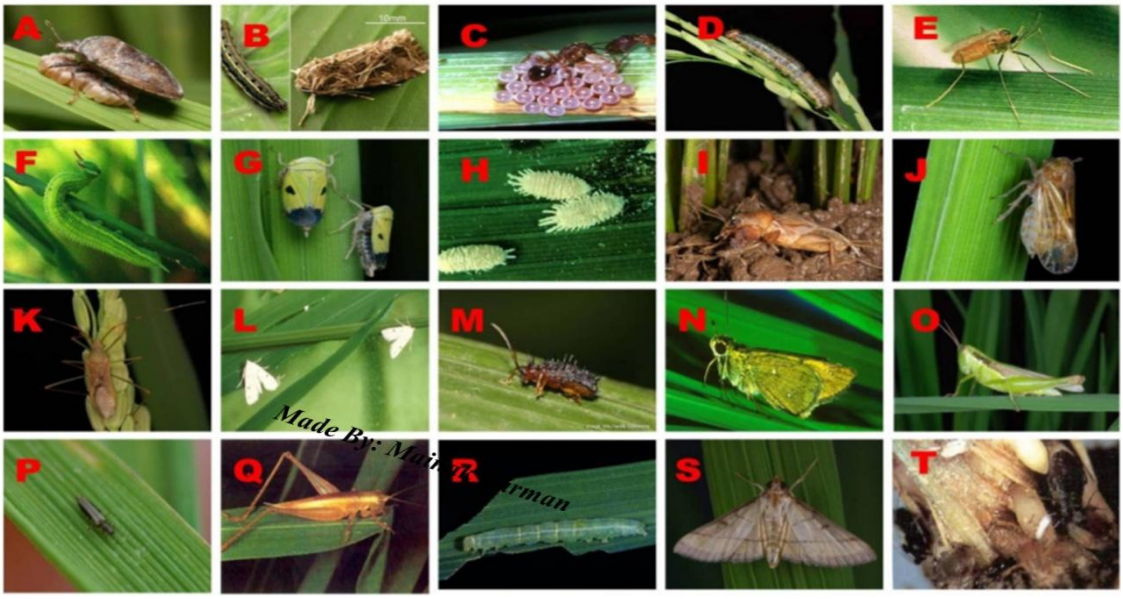

Fig 2. Major insects that attack rice plants. (A) Black bug, (B) Cutworm, (C) Ant, (D) Armyworm, (E) Rice gall midge, (F) Green-horned caterpillar, (G) Green leafhopper, (H) Mealy bug, (I) Mole cricket, (J) Planthopper, (K) Rice bug, (L) Rice caseworm, (M) Rice hispa, (N) Rice skipper, (O) Grasshopper (Short-horned), (P) Rice thrips, (Q) Field cricket, (R) Green semilooper, (S) Rice leaffolder, (T) Root aphid, (U) Rice whorl maggot, (V) Stem borer, (W) Zigzag leafhopper (Image source: Rice Knowledge Bank, IRRI).

Host plant resistance (HPR)

It is the incorporation of some novel heritable traits into the plants so that the plants can avoid, tolerate, or defend the attack of various types of pests in the field condition. Painter (1951) beautifully defined HPR as "The relative amount of heritable qualities possessed by the plant which influence the ultimate degree done by the insect in the field."

Role of HPR in rice IPM

- HPR has excellent compatibility with the other pest management tactics. It easily combines with the different tactics of pest management, due to:
- Resistant host will make the pests weak or will suppress the population so that less quantity or lesser rounds of chemicals or botanicals will control the pest.
- Due to the weakening or suppression of the pest population, the efficiency of predators, parasitoids, or microbes on the population is increased.

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- The changes, during incorporating resistant genes in the host, make the host physiologically and biochemically strong to resist the attack of insect pests. Host plant resistance can also prevent the biotype development of different insect pests, which is one of the significant problems in rice cultivation.

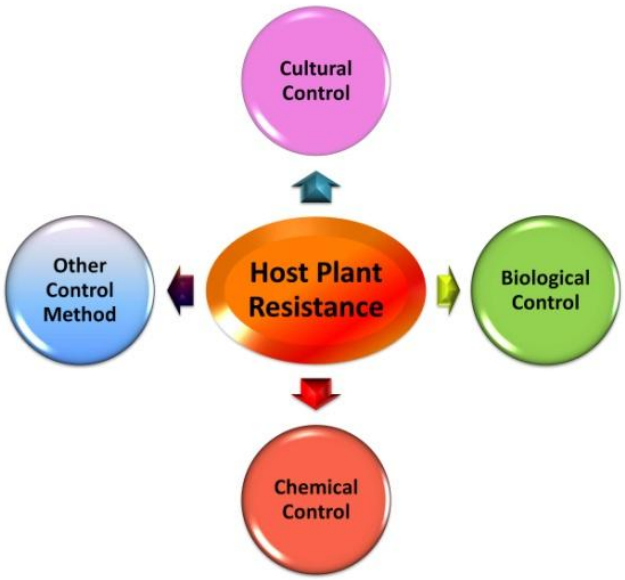

Fig 3. Approaches of Host Plant Resistance

HPR and Cultural control

It involves modification of agronomic practices in cropping system of rice by sowing the early maturing varieties and planting synchronously to avoid heavy insect attack. Synchronous planting of rice reduces potential heavy load dispersal of YSB and BPH (Loevinsohn *et al.* 1988). Planting early maturing rice cultivars efficiently suppress different pest population of rice. BPH generally starts to attack heavily from its 3rd generation. Planting rice plants in the very of the season or by planting early varieties of rice can save the plants from the attack of BPH.

HPR and Biological Control

HPR increases the activity of different biological agents generally that are already present in the fields. Resistant cultivars increase the predation rate of the spider *Lycosa pseudoannulata* on BPH (Kartohardjono and Heinrichs 1984). When BPH attacks on any resistant rice cultivar, due to the incorporated resistant gene, BPH cannot suck the sap from

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the plant properly thus, it becomes restless on the plant, and it becomes easy for the spider to detect BPH.

HPR and Chemical Control

HPR increases the efficacy of several types of insecticide. With a lower amount application of insecticides, it is possible to kill WBPH and BPH, which feed on resistant or moderately resistant rice cultivars compared to those feed on susceptible cultivars. Varieties Naveen, Lalat, and IR-36 have lower YSB and gall midge incidence with the application of HPR and cautious insecticides (Prasad *et al*. 2018).

Major Rice Breeding and Gene Deployment Strategies

1. Sequential release

- It is a gene deployment strategy
- A cultivar with a single major resistance (R) gene replaces a variety with an R gene that has been overcome by the selection for a virulent biotype.
- ***E.g.*** Replacement of IR26, a *Bph 1* gene cultivar, with IR36, a *bph2* gene cultivar (Heinrichs, 1994).

2. Gene Pyramiding

- Strategy of incorporating two or more major R genes into the same cultivar using the pedigree method of breeding is called as gene pyramiding.
- It is an effective method now in rice to develop pest-resistant lines.
- BPH resistance gene *Bph27(t)* and *Bph3* successfully pyramided into commercial *japonica* variety Ningjing3 and *indica* variety 93-11 using this approach (Liu *et al*. 2016).

3. Multiline

- It is the incorporation of a number of collected R genes into isolines and cultivating them in that same field like a mixture.
- These can be used in the field as resistant cultivars also after proper screening (Heinrichs 1994).

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4. Biotechnology

Several biotechnological tools and applications can aid rice breeders to develop new insect-resistant cultivars quickly, and these are gradually becoming popular.

4.1. Wide hybridization

This is an important biotechnological tool where resistance (R) genes are collected from the wild rice and incorporated in the *O. sativa*, edible rice because, in *O. sativa*, R genes are not found.

Table 1. Agronomically important characteristics identified among the wild *Oryza* species

Species	Genome	Chromosome No. (2n)	Characteristics
O. minuta	BBCC	48	BPH, WBPH, GLH, blast, and bacterial blight resistance
O. brachyantha	FF	24	Whorl maggot and stern borer resistance
O. australiensis	EE	24	BPH resistance, drought tolerance
O. punctata	BB, BBCC	24, 48	BPH, WBPH, GLH resistance
O. longistaminata	AA	24	Floral characteristics for outcrossing
O. barthii	AA	24	Bacterial blight resistance
O. glaberrima	AA	24	GLH resistance, early vegetative vigour
O. rufipogon	AA	24	Source of cytoplasmic male sterility, tolerance to stagnant flooding
Oryza. Nivara	AA	24	Grassy stunt virus resistance
O. eichingeri	CC	24	BPH, WBPH, GLH resistance
O. officinalis	CC	24	BPH, WBPH, GLH resistance
O. ridleyi	-	48	Whorl maggot resistance

4.2. Molecular Genetics

These techniques were first applied in rice by the Rockefeller Foundation International Program on Rice Biotechnology established in 1984. Performance of world's first insect-resistant genetically modified (IRGM) rice in China of two *Bacillus thuringiensis* (Bt) lines of cry1Ab/Ac has been impressive fairly with commercial production approval from the Chinese Ministry of Agriculture during 2009 (Chen *et al*. 2011). He *et al*. (2019) showed that

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transgenic microRNA-14 rice had high resistance to the devastating insect rice stem borer. A new gene *BGIOSGA015651 is reported in* Rice varieties TN1 and BG1222 which can regulate the resistance of rice planthopper (Li *et al*. 2020).

Conclusion

HPR is one of the most important management tactics of insect pests in rice. It is a vastly exciting and explorable arena of science. A collaboration of different disciplines when comes across, it becomes best management tactics utilizing resistant cultivars in the fields. Innovative conventional plant breeding techniques and molecular genetics approaches may provide means of developing commercial varieties with stability to variable insect populations.

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SEED PRIMING: A COST EFFECTIVE STRESS MITIGATION STRATEGY

Article Id: AL202111

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Abiotic stresses and environmental pollutions are the main problems of seed germination, emergence and vigour of seedling, which ultimately reduce crop yield. These unfavourable conditions affect plant growth and crop yield by delaying the start of germination and reducing its growth rate. Less availability of nutrients is one of the prime constraints of crop yield. There are a lot of techniques which can be used for enhancing crop yield. Seed priming is one of the suitable techniques to enhance seed germination and emergence. "Seed priming is a pre-sowing treatment which leads to a physiological state that enables the seed to germinate more efficiently". Basically, the metabolic processes necessary for germination are allowed by priming.

Mechanisms of Seed Priming

Generally, the germination of seeds takes three phases. (1) Phase I: seed imbibition phase, in which quick water uptake involves in apoplastic spaces through forces driven by seed. (2) Phase II: Activation phase, in which re-establishment of metabolic activities (protein synthesis takes place) and repairing process and (3) Phase III: Germination phase, where cell elongation and radical emergence occurs. Hydration remains stable in phase II. In the case of priming, I and II phase occurs but not allowing seeds to enter phase III. Before ending of phase II germination remains a reversible process because seeds may be dried again and remain alive during storage which re-initiate germination under suitable conditions.

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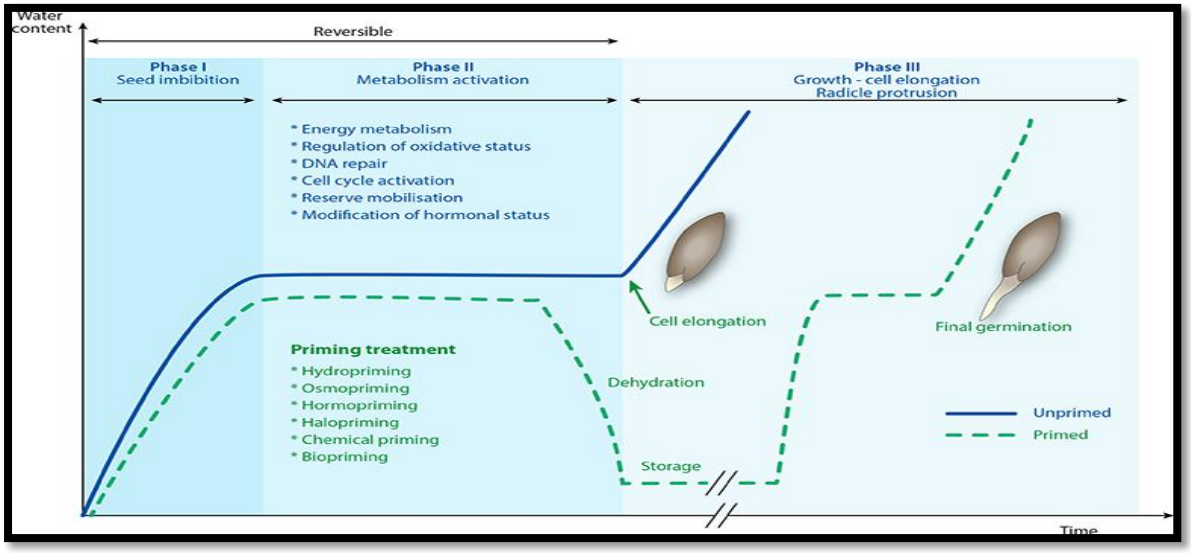
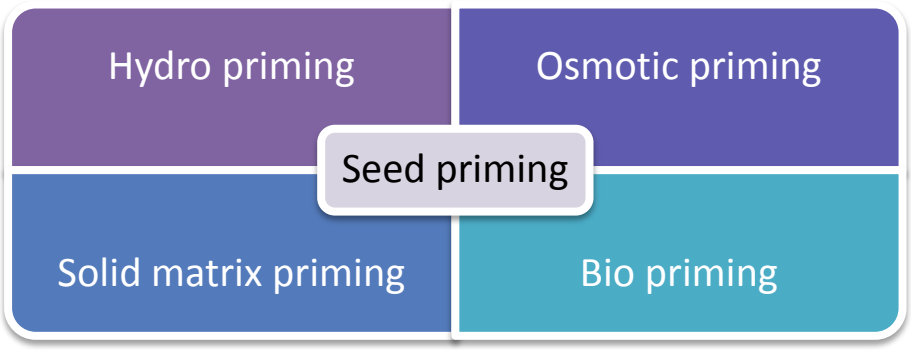


Fig-1 Seed hydration curves and germinating phases in un-primed and primed seeds.

Source: https://www.intechopen.com/media/chapter/51934/media/fig1.png.

Priming Methods

Several methods of seed priming have been developed in order to invigorate seeds and overcome environmental stress. There are mainly four common methods utilized for priming of seeds.



1. **Hydro-Priming:** It is one of the major and most common priming processes where seeds are soaked in water and drying back to storage moisture prior to sowing of the seeds. This decreases the time that seed spends in the seedbed simply imbibing water. Hydro-Priming of seed improves:
    a. Germination percentage
    b. Vigour of seed
    c. Uniform growth
    d. Water use efficiency

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e. Grain yield

2. **Osmotic Priming/ Halo Priming:** Osmotic Priming or Halo Priming refers to the soaking of Seeds in a solution of inorganic salts. In Osmotic Priming, seeds are soaked in solutions containing chemicals such as Polyethylene glycol (PEG), Potassium nitrate (KNO3), Sodium chloride (NaCl), Potassium chloride (KCl), Mannitol, Glycerol, Sorbitol. Priming with salt solutions known as Halo priming. Osmotic Priming of seeds helps in the improvement of germination of Seed, Seedling emergence, establishment and final crop yield in salt-affected soils.
3. **Solid matrix priming:** It involves the incubation of seeds in a solid, insoluble matrix, such as vermiculite, another high water-absorbent polymer, with a limited amount of water, allowing for slow imbibition.
4. **Bio- Priming:** Basically a process of biological seed treatment with the combination of seed hydration and inoculation (the biological aspect of disease control) of seed which protects seed by the beneficial organism. It is an ecological approach using selected fungal antagonists against the soil and seed-borne pathogens.

Besides these types of priming methods, there are some other types of priming likely-

- **Hormopriming:** Here, seed imbibition occurs in the presence of plant growth regulators which have a direct effect on seed metabolism. The growth regulators basically used are Kinetin, Ethylene, Auxin, Gibberellic acid, Abscisic acid, Salicyclic acid etc.
- **Nutripriming:** Seeds are soaked with limited nutrient containing solutions instead of pure water. As a result, both nutritional effect and biochemical advantages of priming which improve germination traits, seed quality and seedling establishment. Priming with Zn improved productivity of chickpea and wheat (Arif *et al*, 2007). In cotton, K-priming promotes favourable effect on growth and nutrient status of cotton seedling under saline conditions (Shaheen *et al*, 2015).

Drying of Seeds after Priming

- Seed drying is essential after the priming process. Seed dehydrator is used for seed drying.
- Slow drying at moderate temperature is generally preferable.
- Heat- shock treatment is also used.

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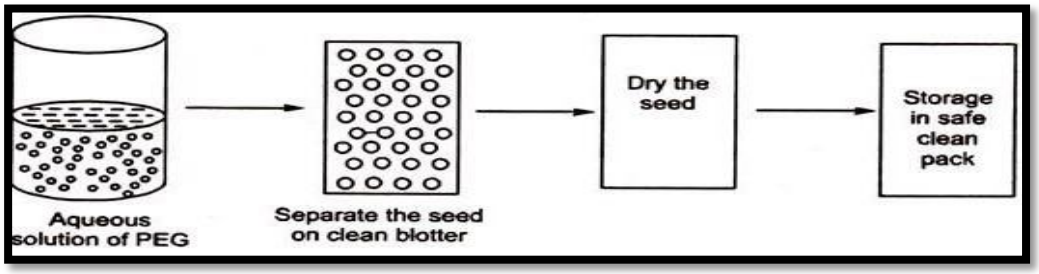

Fig2: Methods of seed drying after priming.

Source: http://www.agricultureinindia.net/wpcontent/uploads/2018/05/clip_image002-111.jpg

Advantages of Seed Priming

- ✓ Faster speed of germination.
- ✓ Increases germination rate.
- ✓ Enables seed to germinate and emerge even under adverse agro-climatic conditions i.e. stress conditions.
- ✓ Improves uniformity to optimise harvesting efficiency and enhance yield potential.
- ✓ Seed performance improved under stress conditions.
- ✓ Protect seed from seed-borne fungi.

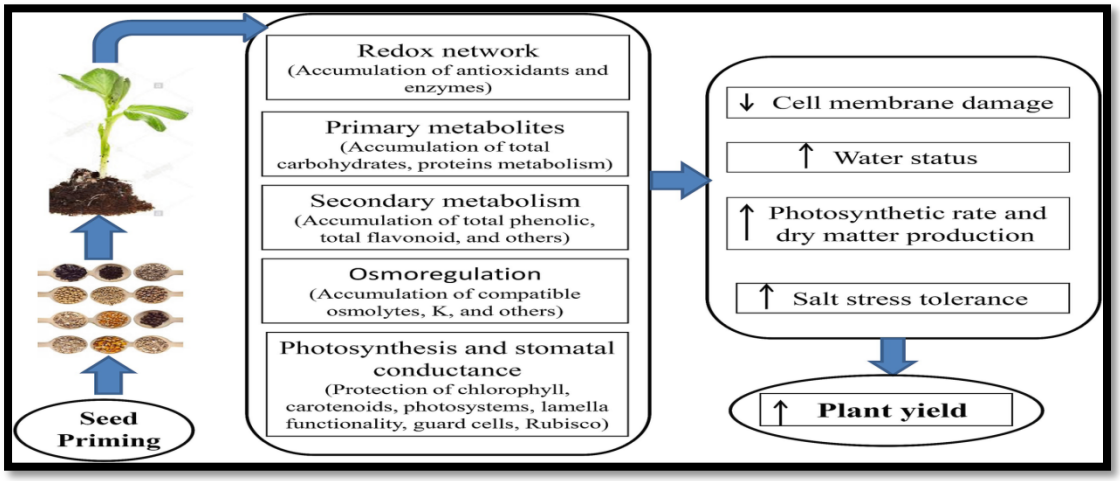

Fig-3 Mitigation of stress by seed priming; Source: Abdelhamid M.T. *et al.* (2019).

Utility of Seed Priming

- ➢ Kaur *et al.* (2002) observed in chickpea that priming increased plant biomass, numbers of branches, flowers, pods and seeds per plant leading to higher seed yield.

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- Several crops like chickpea, maize, rice and wheat under semi-arid conditions reported that yield was increased after seed priming (Harris *et al.* 2001). Major beneficial changes of priming showed in these crops were: faster emergence of crop, better drought tolerance, early flowering and higher grain yield.

Fig-4 Effect of seedling growth in primed and non-primed seeds.

Source: Karthika and vanangamudi (2013).

- Priming at the low and medium concentrations increased the rate of germination of the relatively large chickpea and cowpea seeds compared to an un-primed control.

Fig-5(a) Irregularities in seed germination due to stress conditions. 5(b) Uniformity in prime seeds.

Source: https://www.slideshare.net/GhulamAsghar8/seed-priming-83863812.

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Conclusion

Seed priming is a pre- sowing technique which controlled imbibition of seed followed by dehydration, has become a common trend towards increasing the speed and uniformity of germination and emergence under both stress and normal conditions. The main purpose of priming is to partially hydrate the seed to a point where early phases of germination processes begin, but radicle emergence is prevented, before sowing the Seed (Ahmed *et al*. 2002). Different methods of Priming have advantages and disadvantages and may not all be equally profitable to use in different crops. In general, chemical treatments have been used more often and more effectively than biological treatments. Some biological treatments have also been effectively used in combination with chemical or physical priming treatments to further enhance germination and seedling emergence under non- stress and stress conditions (Haque *et al.* 1995). To determine the effectiveness of different priming techniques, factors such as concentration, a dose of priming agent, the time period for incubation of seed in priming agent, and seed storability must be examined, and the optimal conditions should be determined.

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RECENT PROMOTION OF AGROCHEMICAL FORMULATIONS FOR ECO-FRIENDLY PEST MANAGEMENT

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The indiscriminate use of traditional formulation based (dust, powders, granules, aqueous solutions and mineral oil-in-water emulsions) pesticides during production leads to accumulating pesticide residues in the food commodities after harvest along with environmental pollution. But, in the early 1980s, the consumers and Government emphasized a need for the modern pesticides which are- target specific, effective at lower concentration and safer to the environment. Therefore, the introduction of plant-based products in controlling pests became the need of an hour. But due to the immobility, inactivity of the raw components, they are being formulated and applied in the plants. Biology of the pest, environmental factors, ease of application, formulation type, cost, types of equipment availability, the target surface is the factors considered during the production of an appropriate formulation.

Types of Formulations

The most common formulations are still soluble concentrates for water-soluble chemicals, emulsifiable concentrates for oil-soluble chemicals, and wettable powders and suspension concentrates for insoluble solids. Granules and seed treatments for direct application have also been produced for many years.

Sl. No.	Formulation type	Code
1.	Granules	GR
2.	Solution concentrates	SL
3.	Emulsifiable concentrates	EC
4.	Wettable powders	WP
5.	Suspension concentrates	SC

Table 1: Types of Formulations

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New Advancements Required

Pesticide formulations need to be modified to increase the benefit-cost ratio as well as to optimize the speed of its activity against the pests. The foremost issues that have been dealt with during the production of new generation formulations are- A minimum application of pesticides

- Safety in use and handling
- Disposable or re-usable packing
- Cost-effectiveness
- Reduction of all kinds of effluents and waste

Water Based Advanced Formulations

Suspoemulsions (SE): Microemulsions are transparent dispersions of two immiscible liquids, thermodynamically stable and are stable over a wide temperature range (Hiromoto, 2007). Suspoemulsions can, are mixtures of suspension concentrates and oil-in-water emulsions with added surfactants to prevent flocculation and thickeners from avoiding separation of the dispersed phases. Careful selection of the appropriate dispersing and emulsifying agents is essential to overcome the problem of hetero flocculation between the solid particles and the oil droplets, and extensive storage testing of these formulations is necessary.

Example: Fenpropimorph 24.5 + Epoxiconazole 8.2 SE (Not registered in India)

O/W Emulsions (EW): For safer handling and to lessen or eliminate volatile organic solvents (VOCs) Oil-in-water emulsions are now receiving significant attention. In the case of emulsifiable concentrates, the risk of transportation, handling and the production cost is generally much higher, whereas, oil-in-water emulsions are price worthy and risk is minimum. EW is produced by using block copolymers, non-ionic surfactants and other polymeric surfactants. Droplet size is below 2 microns (volume mean diameter VMD). To avoid separation of the oil droplets, the emulsions are usually thickened with polysaccharides such as xanthan gum and polymers such as polyvinyl alcohol are used as both emulsifier and thickener/stabiliser.

Example: Cyfluthrin 5 EW, Butachlor 50 EW etc.

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Microemulsions (ME): Microemulsions are transparent emulsions and are stable over a wide temperature range. MEs have a very fine droplet size of fewer than 0.05 microns (50 nanometres) and consist of three components, namely:

- oily liquid or solid dissolved in an organic solvent
- water
- surfactant/co-surfactant system

These components form a single phase containing relatively large 'swollen micelles' in which the non-aqueous phase of the active ingredient and solvent are dissolved or solubilised by the surfactant system. In the preparation of microemulsions, two different types of surfactants are needed; one water-soluble and one oil soluble. In microemulsion, the concentration of surfactants can be more than 10– 30%, compared with about 5% for a typical o/w emulsion.

Example: Pyrithiobac Na 5.4 + Quizalofop-P-Ethyl 10.6 ME

Multiple emulsions: It can be oil-in-water-in-oil (O/W/O) or water-in-oil-in-water (W/O/W). These are relatively complex formulations which require meticulous selection of emulsifiers, stabilisers and surfactant for its stability. Multiple emulsions are still in the research phase and could be of interest to reduce the oral toxicity of an active ingredient by restricting it to the primary internal emulsion droplet phase.

Aqueous flowable (AF): Aqueous flowables are concentrated 40% to 70% w/w suspensions of micronized insoluble active pesticide in water. To ensure the dispersion of the pesticide in the water, it requires an active wetting agent and an efficient dispersing agent.

Seed treatment formulations: As a kind of pesticide preparation with film-forming characteristics used for coating of plants and other plant seeds, the seed coating agent is generally prepared by technical material, dispersant, wetting agent, film former, pH regulator, antifreeze, defoamer, other auxiliaries and water (Dayer *et al.*, 2007). Although most pesticide formulations are applied by spraying onto crops or weeds, a significant amount of fungicide and insecticide products are applied onto seeds directly before planting into the soil.

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Products for seed treatment fall into four categories:

water slurriable powders for seed treatment	WS
flowable suspensions for seed treatment	FS
powders for dry seed treatment	DS
non-aqueous solutions for seed treatment	LS

Table 2: Seed Treatment Formulations

Advanced Dry Formulations

Dispersion concentrates (DC): These are formulations of active ingredient dissolved in a water-miscible, polar solvent together with a dispersing or emulsifying agent, designed to dilute in the water giving stable, fine particle size dispersions. DC formulations are alternative to SL, SC, EC and ME formulations, being suitable for active ingredients whose physical, chemical or biological properties preclude the use of these more conventional formulations.

Water dispersible granules (WG): Water dispersible granules (also called dry flowable), developed as attractive alternatives to wettable powders and suspension concentrate, and also a relatively new type of formulation which is safer and more economically viable.

Example: Endosulfan 50 WG, Mancozeb 75 WG, Cypermethrin 40 WG, Captan 83 WG etc

Controlled Release Formulations

Combined/mixed formulation technology: In this unique formulation, two different active ingredients in such a way that one active ingredient, i.e. chlorpyriphos will be quickly available/effective just after application on target pests for quick knock-down effect and on the other hand, the other pesticide, i.e. lambda-cyhalothrin will be efficacious slowly in a controlled manner for long term target pest management

Microencapsulation/capsule suspensions (CS): in recent years, microencapsulation or the polymer membrane technique has become popular among the consumers. Well, a known method of microencapsulation uses the principle of interfacial polymerisation. A typical microencapsulated suspension (CS) formulation is shown below: -

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Ingredients	% by weight
Active ingredient	10–30
Solvent	5–15
Emulsifier	1–5
Anti-settling agents	1–3
Polymer	10–15
Water	to 100

Table 3: Microencapsulated Suspension Formulation

Nanotechnology

Nanoemulsions: Nano-emulsions have a particle size of less than 200 nm, which makes the systems inherently transparent/translucent and kinetically stable. Pesticides formulated with nano-emulsions having a lower surfactant concentration than microemulsions and surfactants are considerably more environmentally friendly and are cost-effective and economically applied to produce nanoemulsions, the energy stored could promote smaller-sized nanoparticles of longer life.

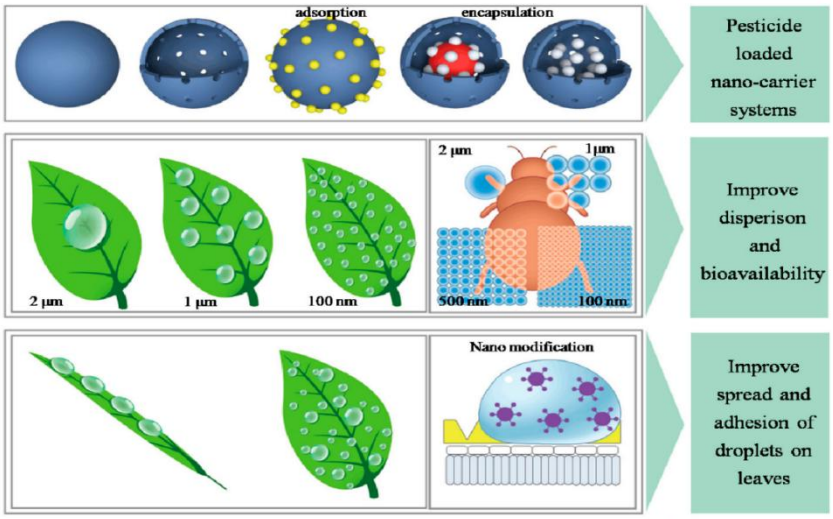

Fig.1. Nano-based pesticide formulation increases the bioavailability and efficacy(O"Sullivan *et al.*, 2010; Sarwar, 2014).

Conclusion

This article has described some of the changes occurring in formulation types employed and the further trends that are driving technologies such as examples of water-

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based dispersion formulation technology for oil-in-water emulsions, suspensions, micro-emulsions etc. New product introduction is an essential factor in brand refreshment, and new formulation technology can impact this considerably. Moving with a lustrous record of providing quality products to its customers and for sustainable pest management, scientists are now shifting its focus towards 'nanotechnology', keeping in view the hazardous effects of highly toxic pesticides.

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