BIOTIC STRESS MANAGEMENT IN CROP PRODUCTION

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The country is facing a very serious challenge of achieving food and nutritional security for its burgeoning population along with the fast decreasing arable land. The biotic stresses (weeds, insects, diseases, nematodes, mites etc.) cause colossal reduction of crop yield year after year, estimated to be around 20-30% depending upon the attack of pests, climatic variations etc. The biotic factors inflict a wide range of detriments to the crop production. Physical damage to produce due to invasion of insects, disease, nematodes, weeds, rodents etc. are threat to both crop production and productivity as well as for securing the produce from any form of loss. If the losses caused by biotic stresses are effectively controlled, a sizable increase in food production is possible.

Biotic stresses that emanated from intensive agriculture were primarily due to anomalous mono-crop of nutritious food source, and the crop husbandry practices with commercial scale production plan did upset the natural food chain and agri-biodiversity by selecting a few organisms in the agro-ecologies. The scenario of pests and their natural enemies in agriculture / horticulture has undergone a considerable change and is likely to continue changing further due to intensive agriculture, diversification in farming, introduction of exotic plant species and new cultivars, and genetic manipulations for development of new plant types for high yield, better quality and tolerance to biotic and abiotic stresses. Though, it may not be possible to predict the exact pest scenario with respect to any specific crop, yet as per current trends, the complexity of pests will increase, with more frequent pest out-breaks in future.

Dr. Anil Dixit has been appointed as the Joint Director of Crop Health Management Research at the ICAR-National Institute of Biotic Stress Management (ICAR-NIB- SM) in Raipur.

Dr Dixit's has unstinted 29 Years' service in ICAR out of which served as an Professor/ Principal Scientist for 13 Years. An alumnus of the Indian Agricultural Research Institute (IARI), his illustrious career spans over three decades, characterised by his profound expertise in teaching, research, extension, and administrative domains. Notably, his dedication and commitment to advancing agricultural science have earned him the privilege of being elected as the Vice-President of the National Weed Science Professional Society.

Dr Dixit's ascent to this prestigious role is anticipated to invigorate the institute's research endeavors, particularly in the realm of crop health management. His experience and leadership are poised to further elevate the institute's standing in the agricultural research.

CLIMATE CHANGE & CHANGING BIOTIC STRESSES SCENARIO

Climate change is likely to pose a potential threat to environment and in turn agricultural productivity, thus seriously influencing country's food and nutritional security. The greatest casualty of climate change will be food, water and livelihood security. Global climate changes affect species distribution, life histories, community composition and ecosystem function. The preponderance of evidence indicates that there will be an overall increase in the number of out-breaks of a variety of insects and pathogens.

Due to very scanty research on direct effect of climate change on pests of various crops in Indian context, it is precisely not yet understood, how these changes will affect crops, pests and their inter-relationship. The potential impact of climate due to various variables is detailed in Table 3.

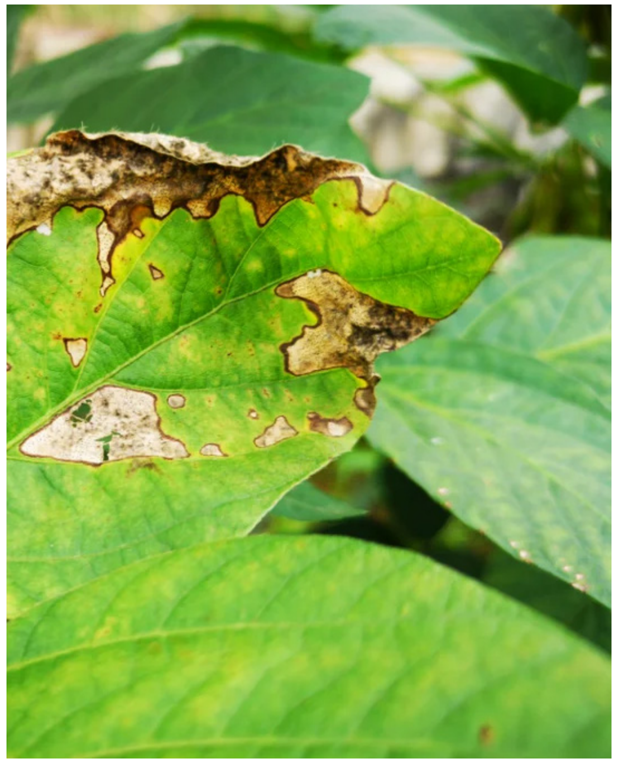
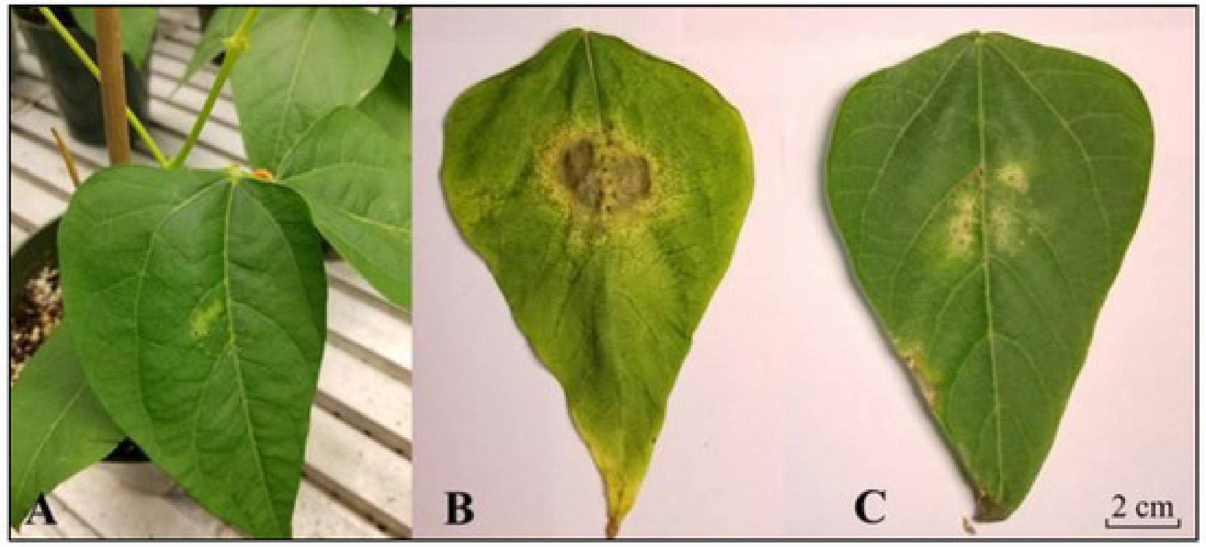
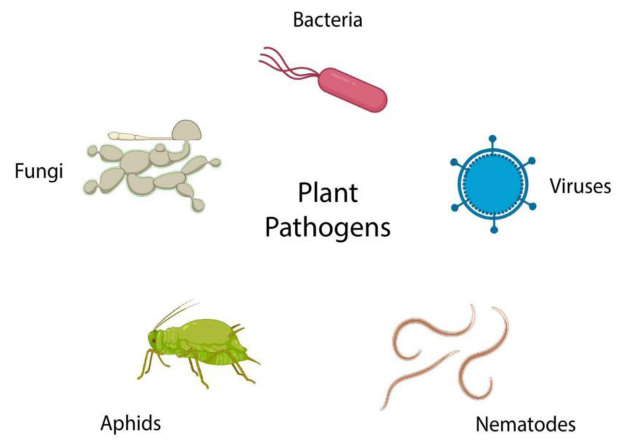


Table 3: Potential Impact of Climate Change

Variable	Mode of action	Effect -/+	Consequences
Increased CO_2	Increased C:N ratio	-	Increase in herbivore feeding: Favour pathogens
	More carbon storage in roots	+	Diminished losses from soil borne pests
Enhanced Temperature	High N_2 lead to luxurious growth	-	Sudden resurgence of insect pests
	Influence the distribution of pests and diseases	- -/+	Increase of 10°C temperature enable species to spread. Unfavourable areas may become suitable.
	Delay in onset of hibernation	-	Prolonged pest activity period -more damage.
	Faster development rate	-	Additional generations
	Predators of aphids on rabi crops may become more active. Disturbances in tri-trophic interaction	+ -	Aiding in biological control of pests. Disruption of biological control process.
	Increased lignifications in forage species	+	√ Many forage spp. become more resistant to fungi
Pollutants (O_3, N_2O)	Adverse effect on plant growth	- +	√ Necro-trophic pathogens colonize on weak plants; Obligate bio-trophic infection may be lessened
Erratic rainfall	Physiology of plants	- -/+	√ Absorption of pesticide √ Parasitoids increase/diminish



PATHOGEN



Broadly defined, disease is any physiological abnormality or significant disruption in the "normal" health of a plant. Disease can be caused by living (biotic) agents, including fungi and bacteria, or by environmental (abiotic) factors such as nutrient deficiency, drought, and lack of oxygen, excessive temperature, ultraviolet radiation, or pollution. In order to protect themselves from damage, plants have developed a wide variety of constitutive and inducible defenses.

Blast of rice remains the most important fungal disease in India. Recent past, severity of sheath blight (*Rhizoctonia solani*) increase in almost all rice growing areas caused major losses to the yield. Similarly, increased occurrence of false smut of rice has been observed in recent years. Among other cereals, wheat is vulnerable to yellow rust pathogen (*Puccinia striiformis*) which is rendering wheat varieties susceptible. Stalk rot, downy mildew and leaf spots are the major constraints in maize crop. The emergence of virulent Tropical race 4 (TR4) of Fusarium wilt has a devastating effect on banana cultivation and has also been detected in India with high incidence and crop damage. In recent years, dry root rot of chickpea (*Rhizoctonia bataticola*) and Phytophthora stem blight of pigeon pea (*Phytophthora drechsleri f.* sp. cajani) have been observed as threats in yield reduction. Soil-borne diseases like *Phytophthora, Pythium, Rhizoctonia solani* and *Sclerotium rolfsii* are flourished well under excess soil moisture in case of pulses. The inevitable climatic changes also affected dynamity of fungal pathogens for increasing frequency of occurrence and severity of diseases. Climate change reduced the efficiency of many Sr genes in wheat which were governing resistance against Ug99 race of *Puccinia graminis* f. sp. tritici. Also, elevated temperature and CO_2 aggravated virulence of Phytophthora infestans causing late blight of potato, *Pyricularia oryzae* causing rice blast and *Rhizoctonia* solani causing sheath blight of rice.

Apparent yield losses of agricultural crops by new bacterial diseases in India are due to infection of phytopathogenic bacteria. Some of them which have emerged with significant importance are bacterial blight of rice (*Xanthomonas oryzae* pv *oryzae*), bacterial blight of pomegranate (X. *axonopodis* pv *punicae*), bacterial wilt of vegetables (*Ralstonia solanacearum*), black spot of mango (X. *citri* pv *mangiferae indicae*), and bacterial blight of cotton (X. *citri sub* sp. *malvacearum*). Apart from these, panicle blight of rice (*Burkholderia glumae*) and stalk rot of maize (*Pectobacterium chrysenthemi* var. *zeae*) have also emerged in the recent years as potential threat to yield of respective food grains in India (Table 2). Host-pathogenic interaction creates biotic stresses causing degradation of crop plant vigour and stands. This stresses occurs due to environment favourism in activating the infestation. Many indigenous techniques are being used to ward off wild animals.

Table 2. Upsurging pests and diseases of agricultural crops as consequences of climate change

Crop	Insect-pest	Disease
Rice	Swarming caterpillar (*Spodoptera mauritia*), Gallmidge (*Orseolia oryzae Wood-Mason*), Brown plant hopper (*Nilaparvata lugens*)	Sheath blight (*Rhizoctonia solani*) and False smut of rice (*Ustilaginoides virens*), Bakane (*Fusarium oxysporum f.* sp. *fujikuroi)*
Wheat	Pink stem borer (*Sesamia inference* Walker), Sugarcane pyrilla (*Pyrilla perpusilla* Walker), Aphid complex: (*Sitobion avenae* F.), Rhopalosiphum maidis (Fitch), Schizaphis graminum (Raandani)	Rice blast (*Pyricularia oryzae* var. *triticum*), Black rust (UG 99) - a potential looming threat to India, yellow rust pathotypes 46S119 and 238S119
Maize	Fall armyworm (*Spodoptera frugiperda* J. E. Smith)	Stalk rot, downy mildew and leaf spots
Chickpea	Blister beetle (*Mylabris pustulata*)	Dry root rot (*Rhizoctonia bataticola*) and collar rot of chickpea (*Sclerotium rolfsii*)
Mung bean/Urd bean	White fly (*Bemisia tabaci*):not a concern but the mosaic virus vectored by it causes severe disease and reduction in crop yield	Stem blight (*Stemphyllium botryosum*)
Pigeon pea	Spotted pod borer (*Maruca vitrata*),	Phytophthora stem blight of pigeon pea
Finger millet	Pink stem borer	Blast (leaf, neck & finger)
Kodo millet	-	Grain smut

VERTEBRATES

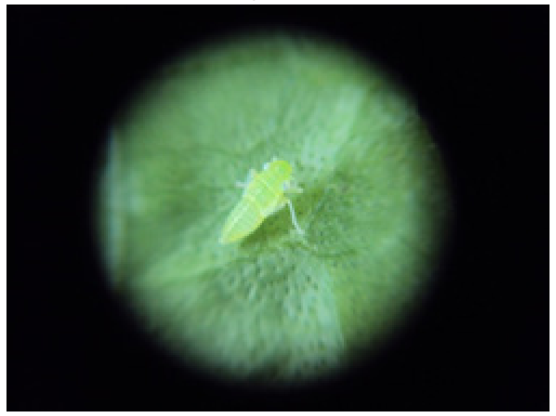
The wild boar (*Sus scrofa*) and langur monkey (*Semnopithecus entellus*) are the mammals gaining pest status and have become great menace for farmers. The wild boar damages crops at all growth stages. Population of wild boars increased as a result of shortage of food stuff in forests compel them to move out for foraging from forest to cultivated lands rigorously and dwindling of natural predators (tiger, panthers, wild dogs and jackal) causal ecosystem disturbance. Several indigenous techniques may be employed to ward off wild boars. Some of such effective ways like spraying of local pigs dung solution (up to 50% damage control), human hair as deterrent (40-50% damage control), erection of used coloured sarees (30-55% control), burning of dried dung cakes (35-50%), planting of thorny bushes and xerophytes around the crop (50-70%), creation of sounds and light through bonfire (40-60%), local dogs for scaring away wild boars (up to 50% control), practiced by local people were scientifically evaluated and validated for efficiency and economic feasibility. Yields are maximized through input intensive farming leads for indiscriminate misuse of fertilizers and pesticides vulnerable to various diseases and pests. On the other hands, non-judicial use of fertilizers and pesticides cause environmental pollution, residual toxicity food stuffs, resistance pesticides in insects and pathogens during natural biocontrol-friendly insects, rise of secondary pests.

Predator ants on jassid

Celosia argentea infested upland

Melilotus alba infested wheat

Sucking pest- mite

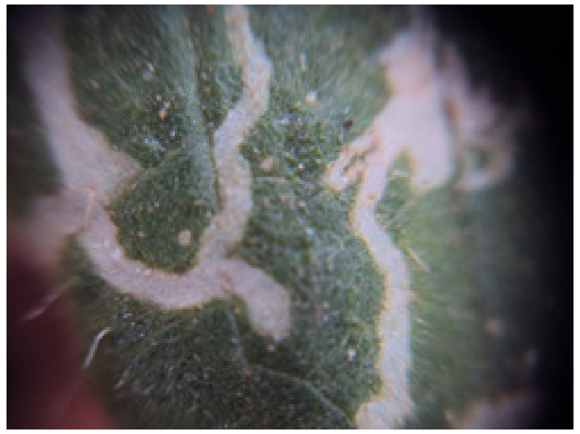


Aphid

Blast disease

Cuscuta infested arhar

Powdery mildew on Phyllanthes niruri



Leaf minor

Gall fly in Chromolaena odorata

Money menance

Fall army worm

Figure 1: Various biotic stresses on crops and weeds

The concept of Good Agronomic Practices (GAP): can be classified in to three categories i.e. (1) Practices, which are usually applied for agricultural purposes not connected with crop protection, such as fertilization and irrigation. They may or may not have a positive or a negative side-effect on disease incidence (2) Practices that are used solely for disease management, such as sanitation and flooding and(3) Practices, which are used for both agricultural purpose and for disease management, such as crop rotation, grafting. The objective of studying the effect of GAP on disease has dual purpose: to develop suitable practices as management methods and to obtain information regarding their impact on diseases when they are used as agricultural practices in order to avoid negative side effect. Cultural practices may be employed, before or after planting. Deep ploughing and flooding are used before planting while irrigation and fertilization can be applied several times during

EFFECTIVE CROP ROTATION CROPPING SYSTEM AND CROP SEQUENCE:

Crop rotation may be defined as the growing of economic plants in recurring succession and in definite sequence on the same land as distinguished from a one crop system usually lacking a definite plan. The cropping system as the sequence or combination of crops growing in a single field. The term "crop sequence" is to be preferred, since it also covers monoculture. The sequential sowing of crops may or may not include fallow or green manure. Fallowing, namely, the absence of crop, may contribute to a reduction in disease incidence although in certain cases continuous cropping (monoculture) may lead to disease decline. The crop rotation program determines the frequency of growing each crop, the list of crops (and fallow periods) during a defined period (cycle), the order (history) of crop (and fallow periods) and the agricultural practices which will be employed during the whole cycle. Monoculture is the opposite of such a practice and is applied ironically, both in very primitive agricultural system (out of ignorance) and in the most advanced ones e.g. greenhouse because out of necessity, specialization in crop production and economic consideration . The effectiveness of crop rotation in disease management will depend on the nature of the pathogen and the crop, the agricultural practices involved, soil properties and other biotic and abiotic factors. The factors that reduce effectiveness of crop rotation in controlling soil borne disease includes (1) wide host range of the pathogen, (2) pathogens having effective mechanisms for survival in the absence of host, (3) Pathogens producing large inoculums densities as resting structures, (4) Crops that are susceptible to several disease, (5) Crop which stimulate formation of resting structures, that are susceptible to several disease, (6) Crops which stimulate formation of resting structures, (7) Frequent infestation of soil with pathogen from external sources, (8) Soil that are conducive to disease and (9) Poor weed management. Most of the diseases caused by soil borne pathogens can be significantly reduced by crop rotation. Examples are wilt of sugarcane, ergot and smut of pearl millet, bunts and flag smut of wheat, leaf smut and bunt of rice, bacterial wilt of potato and tomato, and cereal cyst nematode.

The success of crop rotation for disease management depends on proper selection of crops in the sequence. The crop(s) grown between the susceptible host crops should be resistant or immune to the pathogen or should be non host and their root exudates should not directly or indirectly favour survival of the pathogen. In case of pathogens having very large host range such as the root knot nematodes of vegetable crop, choice of the crop from various vegetables is sometimes difficult. The vegetables have to be rotated with cereals like wheat or rice. However, immune or highly resistance varieties of the vegetable crop such as tomato can be included in the rotation. Rotation does not help against pathogens which have strong saprophytic survival ability in absence of the host. A one year rotation for pegion pea wilt is likely to fail if the plant roots which harbour the pathogen do not completely decomposes. In bacterial wilt of potato, only very long rotations can work since the bacterium has unusual longevity in soil. Thus, rice- wheat (both cereals) has become the predominant rotation in most part or India.

INTERCROPPING

Intercropping is one of the important cultural practices in pest management and is based on the principle of reducing insect pests by increasing the diversity of an ecosystem. The diversity created by introducing cluster bean, cowpea, black gram, or groundnut as intercrops in castor resulted in a buildup of natural enemies (Microplitis, coccinellids, and spiders) of the major pests of castor, also resulted in less congenial conditions for insect pests such as *A. janata* and *C. punctiferalis*. As a result of the buildup of natural enemies, there was much less pest incidence and damage in castor intercropped with cluster bean, cowpea, and groundnut compared to the castor monocrop. Further, these systems were more efficient agronomically in terms of equivalent yields and land equivalent ratio. Economic analysis also showed that these intercropping systems were more profitable than castor alone. It can be concluded that these systems are better protected from pest attacks, resulting in higher yields and economic returns

CROP AND FIELD SANITATION

Sanitation is a major practice of disease management. Regular removal of diseased plants from a population is an important sanitary precaution. It is one of the effective recommendations in the management of the viral disease of the field crops. For the management of loose smut of wheat and production of disease free seed, rouging is always recommended in seed plots. Roguing of infected plants is recommended in several other diseases, e.g. smut of sugarcane, red rot of sugarcane, downy mildews of sorghum and maize, wilt of pigeon pea and several viral diseases. The two principal aims of sanitation are to prevent the introduction of inoculum, by whatever means, into the field, greenhouse, farm or community and to reduce or eliminate inoculum present in these sites. This is of particular importance in the tropic and can be achieved by flooding, flaming, Solarization, ploughing, chemical treatments to suppress or destroy resting structures, mechanical removal of residues , controlling alternate host (Weeds, Volunteer plants), pruning and other means.

GENERAL IPM PRACTICES

- Deep summer ploughing to expose hibernating eggs, larvae or pupae of bollworms, defoliators, red cotton bug.
- Avoidance of late sowing and excessive use of nitrogenous fertilizers.
- Removal of weeds and alternate host from and around fields
- Cultivation of recommended resistant/ tolerant varieties with synchronous planting in the area.
- Use of Bt. cotton hybrid with 20% refugia against bollworms and defoliators.
- Treatment of seeds with Imidacloprid 70WS @ 7.5 g/kg of cotton seed against sucking insects.
- Installation of pheromone traps in the field at 21 days after germination, for all species of bollworms and Spodoptera @ 5 traps/ha to monitor the pest population density
- Installation of light traps @ 1/ha.
- Installation of yellow sticky traps in the field against whiteflies and aphids.
- Erection of bird perches to enhance the activity of insectivorous birds.
- Release/conservation of predators such as *Chrysoperla carnea, Coccinella septempunctata, Menochilus sexmaculatus*
- Release of egg parasitoid, *Trichogramma chilonis* @1.5 lakh/ha twice at weekly interval starting at 15 days of crop age against bollworms.

Integrated Weed Management (IWM) is a component of integrated crop management. It involves the deliberate selection, integration and implementation of effective weed control measures with due consideration of economic, ecological and sociological consequences". The research approach to the development of an IWM system must take all aspects of the cropping system into consideration.

Strategy for IWM

Integrated weed management is a component of integrated crop management (ICM) which transients all discipline. IWM involves three elements;

1. Multiple tactics (eg., competitive varieties, cultural practices and herbicide usage)
2. Weed population maintained at levels below that cause economic damage, and
3. Conservation of environmental quality.

New management systems and control technologies are needed to develop integrated weed management systems for the altered eco-systems created by conservation tillage production systems.

CONCLUSION

In the era of climate change good agronomic practices are needs of hours to curb the potential damage to be executed by vulnerable pathogens. The estimated potential threat due disease incidences owing to eminent climate change is only a rough estimate based on some simulation models and study conducted under fully controlled conditions, which seems to be realistic, if happened, if happened , the good agronomic practices will play a key role to manage the event, which is often forgotten in modern literature on plant diseases, even through many traditional farmers have adequately managed plant diseases for millennia, primarily with cultural practices, though many of them are sustainable, although some are highly laborintensive. It is important to integrate traditional cultural controls into modern pest management system especially those for management of plant diseases, to greater degree than has been done wonder in the past.