

Agronomic management

for biotic stresses in crop production

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The climate change phenomenon dictates climate resilience practices to uplift the crop production and requires minimizing the potential damage to be executed by vulnerable technologies. Good agronomic practices will play a key role to manage the unpredictable events, which is often forgotten in modern literature on biotic stresses (weed, insect, disease and microbes etc.) even though many traditional farmers have adequately managed plant diseases for millennia. Phytotoxin composition differs among and within species, and production of phytotoxin depends on a variety of biotic and abiotic stresses. 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. 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.

Keywords: Biotic stresses, Cropping systems, Pathogens, Vertebrates, Weeds

B IOTIC stress is a new dimension of scientific study as complex form between casual agents and hosts. In India, the annual yield loss of agricultural crops due to biotic stresses is to the tune of 30-35% . Several factors are responsible for biotic stresses such as shift of secondary causal agents to primary

status, injudicious use of pesticides, climate change, resistant pest populations, invasive pests, biotype development, human interventions, etc. Build up of biotic stresses in nature is a continuous process, particularly in favourable environments. Environmental aberrations often may cause

emergence of new pathogenic races/ biotypes. Pathogens and insect pests prevailing with minor status acquire major proportion due to enhanced adaptation capabilities owing to mutational changes for survival. The agricultural crops are also vulnerable to threats from exotic pests/ pathogens/weeds which may get

Table 1. Upsurging pests and diseases of agricultural crops as consequences of climate change

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



Celosia argentea infested upland



Melilotus alba infested wheat



Cuscuta infested pigeonpea

purposefully or accidentally introduced to the country or new areas, in addition to the natural dispersal.

Many pests and diseases are likely to impact in many crops due to climate change.

Weeds

Crops are most sensitive to weeds during early to mid-establishment (the critical weed-free period). In most of the modern agricultural systems, resources such as water, nutrients, and light are rarely limiting during the crop-weed-competition period. Plants grown adjacent to weeds had reduced leaf area, biomass, and yield and displayed the same characteristic responses as crop grown under weed-stressed field condition.

Based on the intensity and nature of weed flora, 30-50% yield reduction was observed in field crops. The weed-suppressive capacity of crop may depend on the species chosen and their composition of phytotoxin and morphological features. Phytotoxin composition differs among and within species, and production of phytotoxin depends on a variety of biotic and abiotic stresses. Moreover, the allelopathic effects of individual phytotoxic compounds may be weed specific. Mixed species communities also may contribute to improved soil coverage and physical mechanisms of weed suppression. The effect of farming on the density and diversity of the weed seed bank depends on governing factors. The

Table 2. Yield loss of crops due to weeds

Crop	Yield loss (%)	Crop	Yield loss (%)
Chickpea	10-15	Pigeon pea	20-30
Finger millet	50-60	Pea	10-50
Green gram	10-45	Rice	10-100
Horse gram	30-35	Sorghum	45-69
Lentil	30-35	Vegetable	30-40
Maize	30-40	Wheat	10-60
Niger	20-30	Soybean	10-100
Ground nut	30-80	Jute	30-70

yield loss estimate of different crops is given in Table 2.

Pathogens

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. In the recent past, severity of sheath blight (*Rhizoctonia solani*) increased in almost all rice growing areas and caused major losses to the yield. Similarly, increased occurrence of false smut of rice has been observed in recent years. Wheat is most susceptible to yellow rust (*Puccinia striiformis*). Stalk rot, downy mildew and leaf spot diseases are the major constraints in maize crop. 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* flourished well under excess soil moisture in case of pulses. The climate change also affected dynamics of fungal pathogens in increasing frequency of occurrence and severity of diseases. Also, elevated temperature and CO₂ 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



Blast in rice

(*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 chrysanthemi* var. *zeae*) have also emerged in the recent years as potential threat to yield of respective food grains in India. Host-pathogenic interaction creates biotic stresses causing degradation of crop plant vigour and stands.

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 diseases 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 for 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 principle 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.

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. The cropping system is defined 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 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. The structure of survival and its longevity in soil should be known to decide the length of rotation or gap between the susceptible crops. A one-year rotation for pigeon pea wilt is likely to fail if the plant roots which harbour the pathogen do not completely decompose. In case of bacterial wilt of potato, only very long rotations can work since the bacterium has unusual longevity in soil, (Both cereals) has become the predominant rotation in most part or India.

Good Agronomic Practices (GAPs) for disease management include (1) practices that 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, viz. to develop suitable practices as management methods and to obtain information regarding

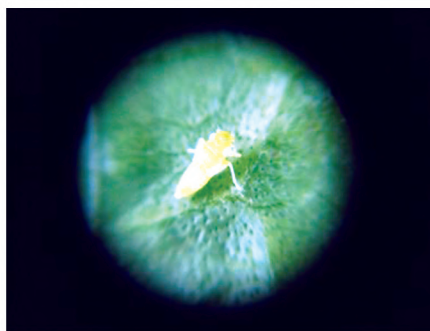
Table 3. Estimates of crop losses due to insect pests (%)

Crop	Range of pest loss (%)
Cotton	18 - 50
Rice	10 - 25
Oilseeds	5 - 35
Pulses	5 - 30
Groundnut	5 - 15
Wheat	3 - 11.4
Maize	5 - 25
Sorghum and millets	3.5 - 35
Sugarcane	10 - 20

Insect Pests



Sucking pest-mite



Aphid



Gall fly in *Chromolaena odorata*



Fall army worm

their impact on diseases when they are used as agricultural practices in order to avoid negative side effect. Estimates of crop losses due to insect pests (%) are given in Table 3.

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 sole crop. 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

Vertebrates

The wild boar (*Sus scrofa*) and langur monkey (*Semnopithecus entellus*) have become great menace



Monkey menace

for farmers. The wild boar damages crops at all growth stages. Several indigenous techniques may be employed to ward off wild boars. Some of such effective ways like spraying of local pig 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.

SUMMARY

In the era of climate change, good agronomic practices are need of the hour to curb the potential damage to be executed by vulnerable pathogens. The estimated potential threat due to disease incidences owing to imminent climate change is only a rough estimate based on some simulation models and studies conducted under fully controlled conditions, which seems to be realistic, 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 labour intensive. It is important to integrate traditional cultural controls into modern pest management systems especially those for management of plant diseases, to a greater degree than has been done wonder in the past.

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