INTEGRATED PLANT DISEASE MANAGEMENT

Aim: To acquaint the students with Integrated Plant Disease Management

Integrated Disease Management

Integrated disease management (IDM) came under focus in 1960's when chemicals especially, fungicides and insecticides came under the attack from environmentalists due to the overuse of chemicals that created the problems of environmental pollution, chemical residues in food stuff, land, water and air, and the associated health hazards.

- It focused on the other methods of disease control.
- It involved cultural, biological, epidemiological and alternative means to achieve the disease control.
- Nowadays, there is an emphasis on disease "management" rather than on "Control".

Definition of IDM

"**Disease management system that in the context of associated environment and population dynamics of microorganisms, utilizes all suitable techniques and methods in a manner as compatible as possible and maintains the disease below economic level"**.

- In general, it is the integration of all possible and suitable management techniques for the control of diseases.
- The practices which need to be avoided in IDM are indiscriminate use of fungicides, monoculture and growing of susceptible cultivars.
- Integrated disease management ensures the proper management of soil health, use of healthy seeds and planting material, application of fungicides when required, field sanitation, cultural practices which suppress the disease , use of bio-control agents and growing resistant plant genotypes .

Different Approaches of Integrated Disease Management System

1. The combined control approach

It is a combination of control methods like adjustment in sowing time, seed treatment, use of resistant variety, chemical spray schedule etc. This type of IDM is widely practiced as a package of practice where the occurrence of disease is certain and sure.

2. The surveillance based approach:

It is an advanced IDM approach based on crop health monitoring and surveillance, and takes into account the economic threshold levels or economic damage levels.

3. Advanced integrated disease management system

It involves the high input technology like computer supported forecasting, remote sensing, scouting, multiple pathogen thresholds, information on life cycle of pathogens, epidemiology of diseases, environmental factor and knowledge based decision making.

Main components of integrated disease management (IDM)

1. Host resistance
2. Induced systemic resistance
3. Genetically improved plants
4. Cultural practices
5. Physical methods
6. Plant nutrition
7. Biological control
8. Use of pesticides of plant origin
9. Judicious use of chemicals

Host resistance

- Resistant varieties can be the simple, practical, effective and economical method of plant disease control.
- Apart from ensuring protection from diseases, they can also save time, money and energy spent on other methods of control and avoid environmental pollution with chemicals.
- They are the only practical method of controlling such diseases as wilts, rusts and others caused by viruses in which chemical control is very expensive and impractical.
- In low value crops, where other methods are often too expensive, development of varieties resistant to common and important diseases can be an acceptable recommendation for the farmers.
- Disease resistance in plants is also governed by their genetic constitution and can be monogenic, oligogenic or polygenic.

Advantages of host plant resistance

- No adverse effect on environment and man, rather the resistant cultivars put a constant and cumulative effect on pathogen.
- Host plant involves no extra cost to the farmers and does not require inputs and application skills.

Disadvantages of host plant resistance

- The development of pathogen resistant variety takes 5-10 years.
- Host plant resistance can put a selection pressure on pathogen to the extent that it may lead to the evolution of new biotypes of pathogen.

- Introduction of varieties with resistance to one pathogen leads to the emergence of new pathogen problem because of the absence of competition from the key pathogen.

Induction of host resistance

- Plants actively respond to a variety of environmental stimuli, including gravity, light, temperature, physical stress, water and nutrient availability.
- Plants also respond to a variety of chemical stimuli produced by soil- and plant- associated microbes.
- Such stimuli can either induce or condition plant host defence through biochemical changes that enhance resistance against subsequent infection by a variety of pathogens.
- Induction of host defence can be local and/or systemic in nature depending on the type, source, and amount of stimuli.
- The **systemic acquired resistance** (SAR) is mediated by salicylic acid (SA), a compound which is frequently produced following pathogen infection and typically leads to the expression of pathogenesis-related (PR) proteins.
- These PR proteins include a variety of enzymes, some of which may act directly to lyse the invading cells, reinforce cell wall boundaries to resist infections, or induce localized cell death.
- Whereas, the **induced systemic resistance** (ISR) is mediated by jasmonic acid (JA) and/or ethylene, which are produced following applications of some non-pathogenic rhizobacteria.
- Interestingly, the SA- and JA- dependent defense pathways can be mutually antagonistic, and some bacterial pathogens take advantage of this to overcome the SAR.
- Pathogenic strains of *Pseudomonas syringae* produce coronatine, which is similar to JA, to overcome the SA-mediated pathway.
- Because various host-resistance pathways can be activated to varying degrees by different microbes and insect feeding, it is plausible that multiple stimuli are constantly being received and processed by the plant.
- Thus, the magnitude and duration of host defence induction will likely vary over time.

Genetically improved plants

- Genes from plants, microbes and animals can be combined and introduced in to the living cells of other organisms, and the organisms that have genes from other species inserted into their genome are called **transgenics**.

- Production of disease resistant transgenic plants has been achieved by this method; certain genes are inserted in to plant genome that confer resistance to pathogens such as viruses, fungi and insects.
- These transgenic plants reduce the pesticide use and thereby provide environmental benefits while reducing farmers cost.
- Genetically modified plants are generally used to control the viral diseases, e.g., a transgenic papaya cultivar „Rainbow" has been developed which is resistant to *papaya ring spot virus* in the US.

Integration of different cultural practices

- Different cultural practices like crop rotation, mulching, tillage, different soil amendments, soil solarization, soil sterilization, change in date of sowing, plant spacing etc. when applied alone are able to control diseases up to some extent; but when these cultural practices are combined with each other, they not only control the diseases but also increase the yield of crops.
- The inter-cropping of maize and sorghum with peppers serves as barriers against the aphid vectors of pepper veinal mottle virus and reduces the virus spread.
- Soil solarization for 40 days along with the addition of cabbage, cauliflower, broccoli and sarson leaf residues controlled the gladiolus wilt (*Fusarium oxysporum* f.sp. *gladioli*) by 74.6% whereas soil solarization (for 40 days) alone reduced the gladiolus wilt by 67.3% compared to the un-solarized control.

Physical methods of disease control

- Solar heat treatment of the water soaked wheat seed in May-June for 5-6 hours provides good control of loose smut of wheat.
- Most of the post harvest diseases can be avoided by irradiation, refrigeration, Controlled Atmosphere Storage etc.
- Soil solarization has been used to control soil borne diseaseS caused by otherwise difficult to control fungi, e.g., *Rhizoctonia solani, Fusarium* spp., *Sclerotium* etc .
- In this the soil beds are first irrigated and then covered with thin (20 µm) transparent mulch in the months of April, May and June.
- It raised the soil temperatures in some cases up to 50^0C, which is deleterious to many plant pathogens in the soil.
- It has been used in raising disease free nursery in tropical and subtropical climatic areas. It also provides excellent weed control.
- Hot water treatment of cabbage seed at 52^0C for 15-20 minutes controls black rot disease (caused by *Xanthomonas campestris* pv. *campestris*).

Plant nutrition

- The nutrition of crop plants has direct effect on the diseases, and is an important component of integrated disease management (IDM).
- Both deficient and over-nourished plants invite high incidence of diseases as well as loss in yield and quality of produce and products.
- The amount, proportion, time and method of application of fertilizers affect the metabolism of plants and thus occurrence and severity of diseases.
- Fertilization with both P and K significantly reduces the leaf rust damage and powdery mildew infection in wheat.
- The deficiency of macronutrients may also affect the incidence of many diseases.
- Potassium (K) plays an important role in survival of crop plants under environmental stress conditions.
- Potassium also affects the reaction of plants to pests or diseases by having direct effect on the pathogen number, development, multiplication, survival, vigour and length of life cycle.

Biological control

- Biocontrol agents are used as a core component of integrated disease management system.
- The science and art of using living organisms as biocontrol agents is an important component of environment friendly disease management procedures.
- These biocontrol agents are of enormous value in integrated diseases management for sustainable agriculture where they often replace the need of fungicides.
- The biocontrol agents either suppress the pathogen growth either by the antibiotic production, hyperparasitism or by competition.
- Various biocontrol agents used in control of various diseases are *Bacillus subtilis, Pseudomonas fluorescens, Gliocladium* spp., *Trichoderma* spp., *Chaetomium globosum, Pseudomonas cepacia, Bacillus cereus, Agrobacterium radiobacter* etc.
- *Trichoderma viride* is the most important and versatile biocontrol agent used for the control of a number of plant pathogens like *Rhizoctonia solani* and *Sclerotium rolfsii* which are otherwise difficult to control by other methods.
- Similarly, *Fusarium lateriticum* has been used to cover primary wounds of apricot for avoiding the canker disease caused by *Eutypa armeniacae.*

- Application of *Peniophora gigantea oidia* paste on pine stumps provided effective control of *Heterobasidion annosus* root rot disease which spreads through unprotected stumps left over after felling.
- *Ampelomyces quisqualis* and *Darluca* spp. hyperparasitize powdery mildew and rust fungi, respectively, and therefore exploited for their biological control.
- *Agrobacterium radiobacter* K-84 strain has been used against crown gall disease world over.

Use of pesticides of plant origin

- Pesticides of plant origin are derived from plant parts and their genes are also used to transform crops to express resistance to insect, fungal and viral attack.
- The plant parts and their extracts with antifungal properties play an important role in plant disease management.
- Plants with pest killing properties have been recorded as early as Rig Veda in India.
- Garlic (*Allium sativum*) has a long history of reputed value and actual use for its medicinal, antimicrobial and pesticidal properties.
- The growth of *Rhizoctonia solani* can be reduced with ethanolic extracts of *Eucalyptus* sp., *Chenopodium ambrosioides*, *Lippia alba*, *Aegle marmelos* and *Cestrum diurnum* leaves.
- The seed extract of *Piper nigrum* was found to be effective against *R. bataticola.*

Judicious use of fungicides

- Chemicals have been used successfully to combat the ravages of these diseases for many years.
- Fungicides with different modes of action like protective (broad spectrum fungicides), post infection activity (EBI), pre- symptom and post symptom (benzimidazoles and triazoles) may be used for controlling a wide array of plant diseases ravaging various crops.
- The over-use of these chemicals resulted in water pollution, residues on food and fruit crops, effect on non- target organisms and development of resistance in pathogens against the chemicals have drawn the attention toward the rational use of fungicides by including monitored control strategies and cultural practices.

Types of Integrated Disease Management

i) Integration of cultural and chemical control

- The integration of chemicals and cultural practices (including improved cultivars) has resulted in a continuous supply of fresh watermelons, reduced diseases caused by

Colletotrichum lagenarium, *Pseudomonas syringae* pv. *lachrymans* and
Pseudoperonospora cubensis.

- The covering the tomato nursery seedlings with nylon net for 25-30 days plus 4 sprays of monocrotophos at 10-days intervals after transplanting, delayed the spread of *Tomato leaf curl virus* for 3-5 weeks and increased tomato yields.

ii) Integration of chemical and biological control

Bio-control agents such as *Pseudomonas fluorescens, Trichoderma viride, T. harzianum, Bacillus subtilis, Pseudomonas putida*, *P. cepacia, Talaromyces flavus,* and *Agrobacterium radiobacter* strain K 84 etc. can be used with integration of chemicals for the effective control of certain diseases.

iii) Integration of resistance, cultural, biological and chemical control

The integration of cultural practices (crop rotation, good farm hygiene procedures, quarantine), fertilizers, soil fumigation and solarization, pesticides (fungicide transplant dips, soil drench, soil incorporations, seed treatments, trace elements and surfactants), resistant cultivars and biocontrol agents are used for the control of club root (*Plasmodiophora brassicae*) of vegetables.