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Advanced Principles of Plant Disease Management: Strategies for Effective Disease Control

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Management: It conveys a concept of continuous process which is based not only on the principle of eradication of the pathogen but mainly on the principle of minimizing the damage or loss below economic injury level.

Importance: Plant diseases are important because of the losses (qualitative and quantitative) they cause. Loss may occur at any time between sowing of the crop and consumption of the produce. Measures taken to prevent the incidence of the disease, reduce the amount of inoculum that initiates and spreads the disease and finally minimize the loss caused by the disease are called as management practices.

Essential considerations in plant disease Management

1. Benefit-cost ratio
2. Procedures for disease control should fit into general schedule of operations of crop production
3. Control measures should be adopted on a **co-operative basis** over large adjoining areas. This reduces frequency of applications, cost of control and increases chances of success of control measures
4. Knowledge aspects of disease development is essential for effective economical control. Information is needed on the following aspects

a. Cause of a disease
b. Mode of survival and dissemination of the pathogen
c. Host parasite relationship
d. Effect of environment on pathogenesis in the plant or spread in plant population

5. Prevention of disease depends on management of primary inoculum
6. Integration of different approaches of disease management is always recommended

General principles of plant disease management

1. **Avoidance**: Avoiding disease by planting at times when, or in areas where, inoculum is ineffective due to environmental conditions, or is rare or absent
2. **Exclusion of inoculum**: Preventing the inoculum from entering or establishing in the field or area where it does not exist
3. **Eradication**: Reducing, inactivating, eliminating or destroying inoculum at the source, either from a region or from an individual plant in which it is already established
4. **Protection**: Preventing infection by creating a chemical toxic barrier between the plant surface and the pathogen
5. **Disease resistance (Immunization)**: Preventing infection or reducing effect of infection by managing the host through improvement of resistance in it by genetic manipulation or by chemical therapy.

Avoidance of the pathogen: These methods aim at avoiding the contact between the pathogen and susceptible stage of the crop. This is achieved by

a. Proper selection of geographical area
b. Proper selection of the field
c. Adjusting time of sowing
d. Disease escaping varieties
e. Proper selection of seed and planting material

a) Proper selection of geographical area: Many fungal and bacterial diseases are more severe in wet areas than in dry areas. Cultivation of bajra in wet areas is not profitable due to the diseases, smut (Tolyposporium penicillariae) and ergot (Claviceps microcephala).

b) Proper selection of the field: Proper selection of field will help in the management of many diseases, especially the soil borne diseases. Raising of a particular crop year after year in the same field makes the soil sick, where disease incidence and severity may be more.

Ex: Wilt of redgram, late blight of potato (Phytophthora infestans), green ear of bajra (Sclerospora graminicola), etc.

c) Time of sowing: Generally pathogens are able to infect the susceptible plants under certain environmental conditions. Alteration of date of sowing can help in avoidance of favourable conditions for pathogen.

Ex: Rhizoctonia root rot of redgram is more severe in the crop sown immediately after the rains. Delayed sowing will help in reducing the incidence of disease.

Ex: Infection of black stem rust of wheat (Puccinia graminis tritici) is more in late sowing, hence, early sowing helps in reduction of stem rust incidence.

d) Disease escaping varieties: Certain varieties of crops escape the disease damage because of their growth characteristics. Ex: Early maturing varieties of wheat or pea escape the damage due to Puccinia graminis tritici and Erysiphe polygoni, respectively.

e) Proper selection of seed and planting material: Selection of seed and seedling material from healthy sources will effectively manage the diseases such as loose smut of wheat (Ustilago nuda tritici), bunchy top of banana (Banana virus-1), Panama wilt of banana (Fusarium oxysporum f.sp. cubense) and whip smut of sugarcane (Ustilago scitaminae). Potato seed certification or tuber indexing is followed for obtaining virus free seed tubers. Citrus bud wood certification programme will help in obtaining virus free planting material.

Exclusion of the pathogen: These measures aim at preventing the inoculum from entering or establishing in the field or area where it does not exist. Different methods of exclusion are seed treatment, seed inspection & certification, and plant quarantine regulation.

a) Seed inspection and certification: Crops grown for seed purpose are inspected periodically for the presence of diseases that are disseminated by seed. Necessary precautions are to be taken to remove the diseased plants in early stages, and then the crop is certified as disease free. This practice will help in the prevention of inter and intra regional spread of seed borne diseases.

b) Plant quarantine regulation: Plant quarantine is defined as " a legal restriction on the movement of agricultural commodities for the purpose of exclusion, prevention or delaying the spread of the plant pests and diseases in uninfected areas".

Plant quarantine laws were first enacted in **France** (1660), followed by Denmark (1903) and USA (1912). These rules were aimed at the rapid destruction or eradication of barbery bush which is an alternate host of Puccinia graminis tritici.

In India, plant quarantine rules and regulations were issued under **Destructive Insects and Pests Act (DIPA)** in 1914. In India, 16 plant quarantine stations are in operation by the

"Directorate of plant protection and quarantine" under the ministry of food and agriculture, government of India.

Plant quarantine measures are of 3 types.

1. **Domestic quarantine**: Rules and regulations issued prohibiting the movement of insects and diseases and their hosts from one state to another state in India is called domestic quarantine. Domestic quarantine in India exists for two pests (Rooted scale and Sanjose scale) and three diseases (Bunchy top of banana, banana mosaic and wart of potato).

Bunchy top of banana: It is present in Kerala, Assam, Bihar, West Begal and Orissa. Transport of any part of Musa species excluding the fruit is prohibited from these states to other states in India.

Banana mosaic: It is present in Maharashtra and Gujarat. Transport of any part of Musa species excluding the fruit is prohibited from these states to other states in India.

Wart of potato: It is endemic in Darjeeling area of West Bengal, therefore seed tubers are not to be imported from West Bengal to other states.

2. **Foreign quarantine**: Rules and regulations issued prohibiting the import of plants, plant materials, insects and fungi into India from foreign countries by air, sea and land. Foreign quarantine rules may be general or specific. General rules aim at prevention of introduction of pests and diseases into a country, where as the specific rules aim at specific diseases and insect pests. The plant materials are to be imported only through the prescribed ports of entry.

1. **Airports**: Bombay (Santacruz), Calcutta (Dum Dum), Madras (Meenambakam), New delhi (Palam, Safdarjung) and Tiruchurapally.
2. **Sea ports**: Bombay, Calcutta, Vishakapatnam, Trivandrum, Madras, Tuticorin, Cochin and Dhanushkoti.
3. **Land frontiers**: Hussainiwala (Ferozpur district of Punjab), Kharla (Amritsar district of Punjab) and Sukhiapokri (Darjeeling district of West Bengal)

3. Total embargoes: Total restriction on import and export of agricultural commodities.

Phytosanitary certificate: It is an official certificate from the country of origin, which should accompany the consignment without which the material may be refused from entry.

Plant diseases introduced into India before/after enforcement of plant quarantine laws:

S.No.	Disease	Year	Introduced into	From
1	Late blight of potato	1883	India	Europe
2	Coffee rust	1879	India	Srilanka
3	Flag smut of wheat	1906	India	Australia
4	Downy mildew of grapes	1910	India	Europe
5	Bacterial blight of rice	1964	India	Phillippines
6	Rice blast	1918	India (Madras)	South East Asia
7	Downy mildew of maize	1912	India (Madras)	Java
8	Ergot of bajra	1957	India (Bombay)	Africa
9	Panama wilt of banana	1920	India	Panama canal
10	Bunchy top of banana	1940	India	Srilanka
11	Wart of potato	1953	India	Netherlands
12	Golden cyst nematode of potato	1961	India	Europe

Diseases not entered into India: Swollen shoot of cocoa, leaf blight of rubber and many viral diseases.

Eradication: These methods aim at breaking the infection chain by removing the foci of infection and starvation of the pathogen (i.e., elimination of the pathogen from the area by destruction of sources of primary and secondary inoculum). It is achieved by

a) **Rouging**: Removal of diseased plants or their affected organs from field, which prevent the dissemination of plant pathogens. Ex: Loose smut of wheat and barley, whip smut of sugarcane, red rot of sugarcane, ergot of bajra, yellow vein mosaic of bhendi, khatte disease of cardamom, etc. During 1927- 1935, to eradicate citus canker bacterium in USA, 3 million trees were cut down and burnt.

b) **Eradication of alternate and collateral hosts**: Eradication of alternate hosts will help in management of many plant diseases. Ex: Barbery eradication programme in France and USA reduced the severity of black stem rust of wheat. Ex: Eradication of Thalictrum species in USA to manage leaf rust of wheat caused by Puccinia recondita. Eradication of collateral hosts, such as Panicum repens, Digitaria marginata will help in the management of rice blast disease (Pyricularia oryzae)

c) **Crop rotation**: Continuous cultivation of the same crop in the same field helps in the perpetuation of the pathogen in the soil. Soils which are saturated by the pathogen are often referred as **sick soils**. To reduce the incidence and severity of many soil borne diseases, crop rotation is adopted. Crop rotation is applicable to only root inhabitants and facultative saprophytes, and may not work with soil inhabitants. Ex: Panama wilt of banana (long crop rotation), wheat soil borne mosaic (6 yrs) and club root of cabbage (6-10 yrs), etc.

d) **Crop sanitation**: Collection and destruction of plant debris from soil will help in the management of soil borne facultative saprophytes as most of these survive in plant debris. Collection and destruction of plant debris is an important method to reduce the primary inoculum.

e) **Manures and fertilizers**: The deficiency or excess of a nutrient may predispose a plant to some diseases. Excessive nitrogen application aggravates diseases like stem rot, bacterial leaf blight and blast of rice. Nitrate form of nitrogen increases many diseases, whereas, phosphorous and potash application increases the resistance of the host. Addition of farm yard manure or organic manures such as green manure, 60-100 t/ha, helps to manage the diseases like cotton wilt, Ganoderma root rot of citrus, coconut, etc.

f) **Mixed cropping**: Root rot of cotton (Phymatotrichum omnivorum) is reduced when cotton is grown along with sorghum. Intercropping sorghum in cluster bean reduces the incidence of root rot and wilt (Rhizoctonia solani)

g) **Summer ploughing**: Ploughing the soil during summer months expose soil to hot weather which will eradicate heat sensitive soil borne pathogens.

h) **Soil amendments**: Application of organic amendments like saw dust, straw, oil cake, etc., will effectively manage the diseases caused by Pythium, Phytophthora, Verticillium, Macrophomina, Phymatotrichum and Aphanomyces. Beneficial micro-organisms increases in soil and helps in suppression of pathogenic microbes. Ex: Application of lime (2500 Kg/ha) reduces the club root of cabbage by increasing soil pH to 8.5. Ex: Application of Sulphur (900 Kg/ha) to soil brings the soil pH to 5.2 and reduces the incidence of common scab of potato (Streptomyces scabies).

i) **Changing time of sowing**: Pathogens are able to infect susceptible plants under certain environmental conditions. Alternation in date of sowing can help avoidance of favourable conditions for the pathogens. Ex: Rice blast can be managed by changing planting season from June to September/October.

j) **Seed rate and plant density**: Close spacing raises atmospheric humidity and favours sporulation by many pathogenic fungi. A spacing of 8'X8' instead of 7'X7' reduces

sigatoka disease of banana due to better ventilation and reduced humidity. High density planting in chillies leads to high incidence of damping off in nurseries.

k) **Irrigation and drainage**: The amount, frequency and method of irrigation may affect the dissemination of certain plant pathogens. Many pathogens, including, Pseudomonas solanacearum, X. campestris pv. oryzae and Colletotrichum falcatum are readily disseminated through irrigation water. High soil moisture favours root knot and other nematodes and the root rots caused by species of Sclerotium, Rhizoctonia, Pythium, Phytophthora, Phymtotrichum, etc