*Review Article*_____ *Chapter – 9*

MAJOR DISEASES AND ITS MANAGEMENT UNDER PROTECTED CONDITION

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Abstract

Protected condition is a structure erect with the objective to provide controlled atmospheric conditions up to different extents. They are provided by erecting a structure having cladding materials of either kind e.g. polyhouse, net house, glasshouse etc. A protected condition is a structure or house made of polyethylene. Temperature, humidity and ventilation can be controlled. The interior heats up because incoming solar radiation from the sun warms plants, soil, and other things inside the protected condition. Air warmed by the heat from hot interior surfaces is retained in the structure by the roof and wall.

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Introduction

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Benefits of Polyhouse

- Growing of crops under polyhouse condition is gaining importance in the country because of achieving independence from adverse climate and weather, which ultimately influence the overall productivity and quality of the crop produced.
- Polyhouse are often used in floriculture and nurseries as the economic value of flowers can justify their expense. Polyhouse are often used in floriculture and nurseries as the economic value of flowers can justify their expense.

Problem in Polyhouse

- Due to controlled/modified natural environmental condition, dense population, relay cropping, type of soil, soil temperature, organic matter in soil, cropping pattern, soil pH and conducive soil favours the diseases cause by fungus, bacterial, nematode and viral pathogens in polyhouse.

Strategies for the Management of Diseases in Polyhouse

- In other words, IDM programme implies all the available diseases management approaches including cultural, biological and chemical control with the main objective to keep the disease incidence below economic threshold level.

Why Protected Cultivation…???

- Better quality of produce
- Higher productivity
- Nursery raising and hardening of plants
- Off-season cultivation
- Efficient use of resources

Major States under Protected Cultivation in India

1. Maharashtra
2. Tamil Nadu
3. Karnataka
4. Gujarat
5. Andhra Pradesh

Factors of Severe Incidence of Diseases In Protected Cultivation

1. Type of soil
2. Temperature
3. Moisture
4. Cropping pattern
5. Soil pH
6. Conducive soil
7. Agricultural implements

Major Fungal Diseases in Polyhouse Cultivation

1) Damping Off

Damping-off Cucumber

Damping-off lettuce

2) Wilt

Wilt of Tomato

Carnation Wilt

3) Powdery Mildew

Powdery Mildew of Rose

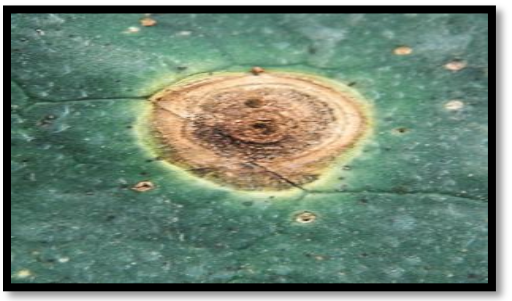
Powdery Mildew of Bell Pepper

4) Downy Mildew

Downy Mildew of Cucumber

5) Alternaria Diseases

Alternaria Disease Spot on Tomato Fruit



Alternaria Disease Spot on Cucumber Leaf

6) Rust

Rust of Carnation

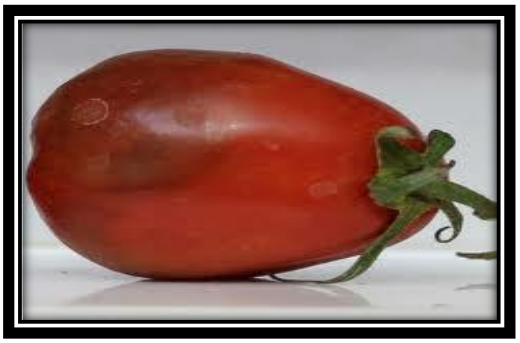
Chrysanthemum Rust

Major Bacterial Diseases in Polyhouse Cultivation

1) Bacterial Wilt

2) Bacterial Soft Rots

Soft Rot of Lettuce



Rot of Tomato

3) Bacterial Leaf Spot

Leaf Spot of Pepper

Spot on Tomato Leaf

Major Viral Diseases in Polyhouse Crops

Cucumber Mosaic Disease (CMV)

Tomato Yellow Leaf Curl* Disease *(TYLCV)

Tomato Spotted Wilt* Disease *(TSWV)

Nematode Disease in Polyhouse Crops

Root-knot Disease

Root-knot nematode in tomato (*M. incognita*)

***(Meloidogyne* spp.)**

Integrated Disease Management

- Integrated plant disease management can be defined as a decision-based process involving coordinated use of multiple tactics for optimizing the control of pathogen in ecologically and economically.

The Implications are:

- Simultaneous management of multiple pathogens
- Regular monitoring of pathogen effects, and their natural enemies and antagonists as well
- Use of economic or treatment thresholds when applying chemicals
- Integrated use of multiple, suppressive tactics.

The Basic Objectives of IDM Program

- Reduce the possibility of introducing diseases into the crop.
- Avoid creating conditions suitable for disease establishment and spread.

Cultural Method

- Manipulation of cultural practices at an appropriate time for reducing or avoiding disease development in crops.
- The cultural practices make the environment less favorable for the pathogen and more favorable for plant.

Destruction of crop residue

- The plant residues that remain in the field after harvest often still contain pests or diseases. They form consequently a source of infection for the next crop. For this reason the destruction of crop residues after the harvest is often recommended.

Sanitation

- Sanitation is one of the most important practices to reduce or avoid plant diseases in Polyhouses.
- Pathogens, such as fungi, bacteria and viruses can survive well in the environment, including in crop residues, soil, tools, clothes, workers' hands etc.
- Proper sanitation practices can reduce pesticide use, costs and prevent yield losses.

Antagonist crops

- In phytopathology, antagonism refers to the action of any organism that suppresses or interferes with the normal growth and activity of a plant pathogen, such as the main parts of bacteria or fungi. These organisms can be used for pest control and are referred to as biological control agents.

Use of resistant variety

- Use of resistant varieties for crop cultivation provides the most cost-effective, the easiest, and the safest of all the methods used for disease control. Both from economic point of view, and the possible health hazards involved in some of other methods of disease control.

Physical Methods

- It is well known that soil harbours a large number of plant pathogens and the primary sources of many plant pathogens happens to be in soil where dead organic matter supports active or dormant stages of pathogens.

Soil Solarization

- In this management tactics, the solar energy is preserved with the help of transparent polyethylene sheet to increase soil temperature (10-15 0^C above

normal temperature) enough to kill the most of the soil-borne pathogens and weeds also.

- Fungal diseases such as damping-off, root rots, stem rots, fruit rots, wilts and blights caused by *Pythium* spp., *Phytophthora* spp., *Fusarium* spp., *S. rolfsii, R. solani*, *Sclerotinia sclerotoirum*, *T. basicola* and *Verticillium* spp. have been successfully managed by soil Solarization.
- Nematode diseases such as *Globodera rostochiensis, Heterodera* spp., and *Meloidogyne* spp. have been successfully managed by soil solarization.
- Bacterial canker of tomato (*Clavibacter michiganensis*).

Steam Sterilization

- Steam is passed through perforated pipes at a depth of 15 cm to sterilize the upper layers of soil. It is mostly practiced under glass house and green house, poly house conditions.

Biological Method

- Biological control is the control of disease by the application of biological agents to a host plant that prevents the development of disease by a pathogen

Bio-Agents

The micro-organisms used in biological control of plant pathogens are known as bio-agents.

Fungal Bio-Agents

- *Trichoderma harzianum*
- *Trichoderma virens*
- *Trichoderma viride*

Bacterial Bio-Agents

- *Pseudomonas fluorescens*
- *Bacillus subtilis*
- *Bacillus cereus*

Chemical Control

- There are two different types of chemical used to manage diseases – protectants and eradicants.
- Protectants sit on the surface of plants and their mode of action relies on contact with pathogens for control. As new growth needs to be protected, growing plants need on-going protectant spray applications. These chemicals generally control a wide range of fungal pathogens. When using protectants, make sure plant coverage is thorough and even.
- Eradicants or curatives are systemic pesticides and are absorbed by plants. Their mode of action controls pathogens at sites some distance away from where the chemical droplets land on the plant. These chemicals may move into new growth and therefore do not need to be applied as often as protectants.

Commonly Major Pesticides used in Polyhouse

Fungicides

- Azoxystrobin, Metalaxyl, Carbendazim

Bactericides

- Streptocycline, copper oxychloride

Nematicides

- Fluopyrum & Fluensulfone

IDM Module for Cucurbits Crop in Polyhouse

Stage	Disease	Practices
Pre- sowing	Nematodes, Damping off	Crop rotation with non cruciferous crop ones in a year. Use organic amendment.
Seed-seedling	Root rot	Seed treatment with *Trichoderma viride* @2gm per 100g seeds. Apply 50g *T. viride* in 10kg FYM all along the rows.
Vegetative	Downy milew, Powdery milew, Leaf spot	Optimum irrigation spray of Dinocap 48% EC 300 ml water/750 ltr. Water per ha. Spray Zineb 1.5 to 2.0 kg a.i./750 to 1000 lt. of water/ha. Spray cymoxanil 8% + mancozeb 64% WP @ 600 g in 200-240 l of water/acre.
Reproductive	Downy milew, Powdery milew,	As per Vegetative stage.

Review

Cucumber

Kader *et al.* (2012) observed that combination of chitosan (0.05 mM) with $CaCl_2$ (20 g/l) and *S. serevisiae* (2x104 cfu/mL) recorded minimum per cent disease incidence of powdery mildew (14.4) in all three treated vegetables *viz.*, Cucumber, Cantaloupe and Pepper followed by treatment combination of Chitosan + K_2HPO_4 (20 mM) and Saccharin +K_2HPO_4 (20 mM). El-Mougy *et al.,* (2013) reported that combination of potassium bicarbonate (20mM) with thyme oil (0.05mM) was recorded minimum disease incidence of downy mildew and powdery mildew of cucumber (11.14% and 11.4% respectively) and pepper (14.2 % and 9.6 % respectively). Patil *et al.* (2017) reported that minimum disease incidence was recorded in case of carbofuran @ 0.1 mg /kg soil followed by higher dose liquid formulation of *Paecilomyces lilacinus* @ 0.5 g/pot and Liquid formulation of bio-agents (*T. viride* + *P. fluorescence* + *P. lilacinus*) @ 15 g/ pot. Singh and balodi (2021)

reported that The combined application of tested bio-agents (*T. harzianum* + *B. subtilis* + *P. fluorescens*) treatment caused significantly (P > 0.05) greatest reduction in root disease caused by *F. oxysporum* and root-rot disease caused by *R. solani* as compared to untreated check. Patil *et al*. (2021) studied that Integration of formalin and neem oil seed treatment reduced nematode population and fungus incidence and increased the yield of cucumber under polyhouse condition.

IDM Module for Cruciferous Crop in Polyhouse

Stage	Disease	Practices
Pre-sowing	Nematodes, Soil borne diseases	Sown on Raised nursery beds. Soil solarization. Use organic amendment. Treat the soil with Fluopyrum 34.48% SC @ 250 to 300 ml per acre
Sowing	Black rot	Seed treatment with Carbendazim 0.01% + 100 ppm Streptocycline sulphate. Seed treatment with T. viride @ 2 gms per 100 g of seed. Apply optimum dose of Nitrogen and Phosphorus fertilizer as basal dose. Adopt optimum irrigation.
Vegetative	Black rot and leaf spot	Spray Mancozeb 75% WP @1500-2000gm/ha.

IDM Module for Solanaceous Crop In Polyhouse

Stage	Disease	Practices
Pre-sowing	Nematodes, Soil borne diseases	Use organic amendment. Treat the soil with Fluopyrum 34.48% SC @ 250 to 300 ml per acre.
Seed & seedling	Damping off , Fusarium wilt	Sown seed on Raised nursery beds. Use *Trichoderma* sp & Pseudomonas biopesticides @ 4 gm per kg seed.
Vegetative	leaf spot	Spray streptomycin sulfate 9% + tetracycline hydrochloride 1% SP solution 40-100 ppm after appearance of first true leaves. Spray Mancozeb 75% WP @1500-2000gm/ha. or azoxystrobin 23% SC @ 200 ml in 200 l of water/acre
Reproductive	Leaf curl	Spray dimethoate 30% EC @ 396 ml in 200-400 l of water/ acre or Imidacloprid 17.8 SL @ 60-70 ml in 200 l of water/acre.

Chili

Gupta *et al.,* (2005) studied that Soil application of *T. harzianum* + sprays of *T. harzianum* (10 ml/lit. of water) recorded minimum wilt incidence (1.66%) in bell paper followed by Soil application of *T. viride* + sprays of *T. viride* (10 ml/lit. of water). Raju *et al*. (2016) found that concluded that, soil application of Metalaxyl MZ or Carbofuran + bioagents applied simultaneously to manage the root galling and *Phytopthora* rot in Capsicum. Yadav *et al*. (2017) found that maximum reduction in disease (69.30%) with minimum per cent disease (17.24) obtained with the application of propiconazole (0.1%) as seed treatment followed by foliar spray of neem (NSKE 5%) resulted in decreased PDI and increased fruit yield during both the year 2015-16 and 2016-17. Sharma and Sharma (2017) reported that chilli sonal, arka lohit and Kashmir long succumbed to bacterial wilt disease completely (100% mortality) and among the parents pusa sadabahar, pant C1, surajmukhi and CH1 genotype/variety of chilli were found to be resistant against bacterial wilt during both the years. Jaiganesh *et al*. (2017) conduct experiment on integrated disease management of chilli anthracnose under polyhouse condition. They found that Seed treatment with *P.fluorescens* @ 10 g/kg of seeds and foliar spray of Salicylic acid @ 50 ppm on 40 DAT along with Foliar spray of Potassium silicate @ 3 % on 60 DAT was the most effective treatment in controlling the chilli anthracnose disease incidence when compared to control and comparison fungicide. Majeed *et al.* (2019) studied effect of different bio-control agents and their combinations on pre-emergence damping-off of chilli under protected condition. They revealed that combination of treatment viz., *T. viride +T. harzianum +P. fluorescens + B. subtilis* recorded minimum pre- and post- emergence damping off disease of 13.33 percent and 15.36 percent respectively. Sahana *et al*. (2020) studied Screening of capsicum varieties/hybrids against stem rot under poly house condition and found that Out of fourteen capsicum varieties/ hybrids *viz*., Red Inspiration and Delisha exhibited immunity against stem rot, whereas Pusa Deepti, Solon Hybrid- 2 and Nemlite expressed resistance.

Tomato

Nagesh *et al.,* (2001) reported that *Paecilomyces lilacinus* + neem cake (10%) + NPK (1:0.5:0.5) recorded minimum root gall index (1.4 scale), minimum nematode multiplication rate (1.56%) and maximum egg parasitisation (53.6% egg masses) of *Meloidogyne incognita* in tomato under polyhouse condition. Anith and Momol, (2004) found that drenching of *Pseudomonas putida* (5ml containing $5x10^8$ cfu/ml) + Actigard (28 mg/l) recorded significantly lower (46.8%) bacterial wilt caused *Ralstonia solanacearum* followed by *Pseudomonas putida* @ $5x10^8$ cfu/ml (53.1%). Banyal *et al.,* (2008) observed that Tebuconazole (0.05%) (soil drenching + seedling dip) + *T. viride* (4 g/kg soil) (soil application) recorded cent per cent disease control of collar rot of tomato caused by *Sclerotium rolfsii*. Vasanthi *et al*. (2017) reported that treatment (*Pf*1 + Chitin + 3% Neem oil) was the best treatment showed very low disease incidence 21.8 per cent and maximum disease reduction over control 68.85 per cent of tomato spotted wilt virus and maximum percent reduction in number of thrips over control was recorded as 70.45 per cent followed by Pf 1 + Chitin under polyhouse condition. Sadana and Didwania (2020) reported that T_5 strain of *T. harzianum* with *Eucalyptus oblique* at 15 per cent give

maximum inhibition (48.7%) followed by T_2 strain of *T. harzianum* with *Eucalyptus oblique* at 15 per cent against *Alternaria solani* of tomato.

Flowers

Sharma *et al.* (2005) studied that Neem cake and *Trichoderma harzianum* emerged as a best treatment in combating the incidence of Fusarium yellows of gladiolus under polyhouse condition as it reduced disease up to 76.31 per cent followed by NC+ Saaf+ *Trichoderma harzianum*.

of all fungicides concentration @ 200 ml/pot. Kshirsagar *et al.,* (2008) studied that Carboxin (0.1%), Iprodione + carbendazim (0.2%), Carboxin (0.05%) + *T. viride* (109 spore/ml), Carboxin (0.05%) + *T. harzianum* (109 spore/ml), Propineb (0.1%) + *T. harzianum* (109 spore/ml), Benomyl (0.1%) and Carbendazim (0.1%) recorded cent per cent control of gerbera root rot caused by *Rhizoctonia solani.* Sonawane, (2013) studied Integrated disease management of the leaf blight of anthurium (*Colletotrichum gloeosporioides*) in polyhouse. He observed that combination of propiconazole (1000ppm) + *T. viride* (0.5x108 cfu/ml) + garlic extract (10%) recorded maximum per cent disease control (84.12%) of anthurium leaf blight.

Other Crops

Sofi *et al.,* (2009) observed that combination of soil solarization, mustard cake and *T. harzianum* (50mg/10gm seed) recorded minimum disease incidence (6.23%) which was with at par combination of solarization and *T. viride* (50mg/10gm seed) (6.69%) pre-emergence mortality. In other experiment combination of solarization, mustard cake and *T. harzianum* (50mg/10gm seed) recorded minimum disease incidence (2.37%) which was with at par combination of solarization and *T. viride* (50mg/10gm seed) (2.47%) in post-emergence mortality in cauliflower. Sivakumar, (2012) reported that Solarized Potting Mixture (SPM) + *T. harzianum* (1g/kg of SPM) + VAM (100 spore/kg of SPM) + Potassium phosphonate (0.3%) recorded minimum per cent rotting (13.3%) and maximum per cent disease reduction (69.0%) against foot rot incidence in black pepper *(Phythophthora capsici*) under protected condition.

Conclusion

It can be concluded that cultural, biological, physical and chemical management practices are promising techniques to reduces the protected condition diseases but, it possesses limited scope when apply as single. Hence, integrated disease management strategies proved to be best for the management of these diseases. The integrated and judicious application of soil solarization, bio-agents (*T. viride, T. harzianum, T. pseudokoningii, P. flurosences, P. putida, Paecilomyces lilacinus, Saccharomyces cerevisiae,* VAM etc.); botanicals (Chitosan, Garlic extract etc.); fertilizers (NPK), organics (Neem cake, mustard cake etc.) and fungicides (Carboxin, Propiconazole, Hexaconazole etc.) by the different methods like soil application, seedling dip, drenching and foliar spray not only manage the protected condition diseases but also enhance growth and production of crops grown under protected condition.

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