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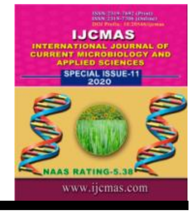

Review Article

Introduction to Disease and Integrated Disease Management in Solanaceous Vegetables

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A B S T R A C T

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Plant diseases are considered an important biotic constraint, which leads to significant crop losses world- wide. Integrated Disease Management (IDM) is a holistic approach which first assesses the disease situation, evaluates the merits of disease management options and then implements a system of complementary management actions within a defined area (Vikas Kumar *et al.,* 2013). Cultural practices as a crop management procedure represents the oldest and most broadly applicable eco-friendly innovative approach with farmers for prevention of losses in crop due to diseases and other causes. Cultural practices are basic but eco-friendly way to minimize diseases. Biological control is defined broadly as the "use of natural or modified organisms, genes, or gene products" to reduce the effects of pests and diseases. Biological approach may provide a better alternative, as activity of natural antagonists can then be encouraged (Anchal Sharma *et al.,* 2013). Physical control is the use of tillage, open-field burning, heat- treatment, and other physical methods, usually to eliminate pests or separate them from the crop. Chemical control is the use of synthetic chemical pesticides to eliminate pests or reduce their effects (Anchal Sharma *et al.,* 2013). Chemicals must be used at recommended rates and application frequencies. Besides selection of the most efficacious material, equipment must be properly calibrated and attention must be paid to the appropriate application technique. Integrated disease management has been described here which comprises cultural, physical, mechanical, genetic, biological and chemical (Abhay K. Pandey *et al.,* 2016). Integrated disease management promotes sound structures and healthy plants. It reduces the need for pesticides and fungicides by using several management methods and reduces the potential for air and ground water contamination. It eliminates issues related to pesticide residue. The success and sustainability of IDM greatly depends on their involvement in helping to generate locally specific techniques and solutions suitable for their particular farming systems and integrating control components that are ecologically sound and readily available to them. Training and awareness of farmers, disease survey teams, agricultural development officers, extension agents and policy makers remains to be an important factor for the successful implementation of IDM strategies.

Introduction

Any biotic or abiotic agents, which induce the disease in plant, are referred as the cause of diseases. Organisms that cause infectious disease include fungi, bacteria, viruses, viroids, virus like organisms, phytoplasmas, protozoa, nematodes and parasitic plants and environmental conditions such as lack or excess of nutrients, moisture, light, etc. to presence of toxic chemicals in air or soil. Plant disease can be defined as "a series of harmful physiological processes caused by continuous irritation of the plant by a primary agent" or "physiological or structural dis-balance in plant caused by certain external agencies.

However, the definition which is accepted by American Phytopathological Society and the British Mycological Society states that "Disease is a malfunctioning process that is caused by continuous irritation which results in some suffering-producing symptoms".

Therefore, the plant disease is a structural abnormality or physiological disorder or both due to an organism or unfavorable conditions that may affect the plant or its parts or products or may reduce their economic value. Integrated Disease Management (IDM) is a concept derived from the successful Integrated Pest Management (IPM) systems which consists of scouting with timely application of a combination of strategies and tactics. These may include site selection and preparation, utilizing resistant cultivars, altering planting practices, modifying the environment by drainage, irrigation, pruning, thinning, shading, etc., and applying pesticides, if necessary. But in addition to these traditional measures, monitoring environmental factors (temperature, moisture, soil pH, nutrients, etc.), disease forecasting, and establishing economic thresholds are important to the management scheme. These measures should be applied in a coordinated integrated and harmonized manner to maximize the benefits of each component.

What is disease?

A disease is an abnormal condition that negatively affects the structure or function of an organism, and that is not due to any external injury or it is also defined as any harmful deviation from the normal structural or functional state of an organism.

However, the definition which is accepted by American Phytopathological Society and the British Mycological Society states that "Disease is a malfunctioning process that is caused by continuous irritation which results in some suffering-producing symptoms".

Any biotic or abiotic agents, which induce the disease in plant, are referred as the cause of diseases. Disease can occur any time and at any stage of the plant growth from the time of sowing of seed to storage (Pandey *et al.*, 2016) (Fig. 1).

Disease development

Three conditions are necessary for disease in plants:

Host plant.

Disease causing organism or pathogen must be present.

Favourable environment for disease organism to develop.

Disease triangle

The interactions of the three components such as host, environment (physical viz., climatic, soil and biotic) and pathogen of disease have been visualized as a triangle generally referred to as the "disease triangle". Each side of the triangle represents one of the three components. The length of each side is proportional to the sum total of the characteristics of each components that favour disease i.e. if the host is resistant, matured and widely spaced, the host side and amount of disease would be small or zero, whereas if the host or plants are susceptible, at susceptible stage of growth or densely planted, the host side would be long and the amount of disease could be great.

Similarly, the virulent, abundant and active the pathogen, the longer the pathogen side and greater is the amount of disease. Also more favourable the environmental conditions (e.g. temperature, moisture and wind) help the pathogen or that reduces the host resistance, longer will be the environmental side and greater will be the amount of disease.

When these three components of the disease triangle are quantified, the area of the area of the triangle represents amount of disease in a plant or in a plant population. If any of the three components is zero, there can be no disease (Pandey *et al.,* 2016).

Disease cycle

A Series of events occurs in succession leads to the development of disease. This chain of events is called disease cycle. Plant disease cycles represent pathogen biology as a series of interconnected stages of development including dormancy, reproduction, dispersal, and pathogenesis.

The progression through these stages is determined by a continuous sequence of interactions among host, pathogen, and environment. The main events of stages comprising the disease cycle include the following:

Inoculation

Inoculation is the initial contact of pathogen with a site of plant where infection is possible. The pathogen that is brought into contact with plant is called inoculum. Inoculum is any part of pathogen that can initiate infection.

Types of inoculum

Primary inoculums

Inoculum that survives dormant in winter or summer and causes original infection in spring or in autumn is called primary inoculum.

Secondary inoculums

Inoculum produced from primary infection.

Dissemination

Dissemination refers to the spread or dispersal of the pathogen from an inoculum source to a host. Dissemination can occur by wind, splashing rain, insects, infested pruning tools, infected or infested transplants, and other means.

Incubation

Incubation is time interval between inoculation and appearance of disease symptoms is called incubation period.

Attachment

All fungi, bacteria are first brought into contact with external surface of plant organs, before they can penetrate and colonize the host, they first become attached to host. The propagules of these pathogens have mucilaginous substances on their surface or at tips and help the pathogen to adhere to plant.

Penetration

Pathogens penetrate plant surfaces by direct penetration by cell wall, natural openings (Hydathodes and Lenticels) and through wounds.

Host recognition

When a pathogen comes in contact with host cell, an early event takes place that triggers rapid response in each organism that either allows or impeds further growth of pathogen and development of disease. Host components acting as signals for recognition and activation of pathogens are numerous.

Infection

Infection is the process by which pathogens establish contact with susceptible cells or tissues of host and procure nutrients from them.

Invasion

After infection, pathogen invades the hosts. e.g. Pathogen causing powdery mildew produce mycelium only on surface of plant but send haustoria into epidermal cells.

Colonization

After invasion into host pathogen makes colonies referred as colonization.

Growth and reproduction

Growth and development of a pathogen usually occurs on or within infected plant tissue. Pathogens continue to grow indefinitely so that the same pathogen spreads into more and more tissues until the spread of infection is stopped or plant is dead. Fungi grow and spread within their host by means of mycelium. Bacteria spread by rapidly increasing in numbers.

Symptom development

All visible and otherwise detectable changes in infected plants make up the symptoms of disease. Symptoms may change continuously from the moment of their appearance until the entire plant dies.

Overwintering or over seasoning

Overwintering or over seasoning is the ability of a pathogen to survive from one growing season to the next.

Dormant period (George N. Agrios, 2006)

Mechanism of plant disease

The pathogen may cause disease in plant by:
Weakening the host by continuously absorbing food from the host cells for their own use. -Killing or disturbing metabolism of host cells through toxins enzymes or growth regulating substances, they secrete.

Blocking the transportation of food, mineral, nutrients and water through the conductive tissues.

Consuming the contents of the host cells upon contact.

Principles of plant disease control

Avoidance

Avoidance prevents disease by selecting a time of the year or a site where there is no inoculum or where the environment is not favorable for infection.

Exclusion

Exclusion prevents the introduction of inoculum. It is legal restriction of the movement of agricultural commodities for the purpose of exclusion of plant disease in uninfected areas. It can be achieved by Seed treatment, Inspection and certification and Quarantine.

Eradication

Eradication eliminates, destroy, or inactivate the inoculum.

Protection

Protection prevents infection by means of a toxicant or some other barrier to infection. It involves physical and chemical control methods.

Resistance

Resistance utilizes cultivars that are resistant to infection.

Therapy

Therapy cures plants that are already infected. It involves chemotherapy and thermotherapy (George N. Agrios, 2006).

Plant disease control

It is very important to remember that correct diagnosis is most important step in control of plant diseases.

Important strategies for management of plant diseases are:

Cultural practices

Cultural practices as a crop management procedure represents the oldest and most broadly applicable ecofriendly innovative approach with farmers for prevention of losses in crop due to diseases and other causes. Successful use of cultural practice for disease control can be made only when complete knowledge on the nature of pathogen and its behavior in different conditions of environment, cropping system etc. are know.

Cultural practices are the only feasible method of disease control in crops which give lower return per unit area or of which resistant varieties are not known (Singh *et al.*, 2012).

Cultural practices includes

Host eradication

Host eradication is carried out to prevent the spread of numerous diseases by eliminating infected plants that provide a ready source of inoculum within the crop. e,g Cucumber mosaic virus overwinters only or mainly in perennials, usually wild plants. Eradication of host in which pathogen overwinters is sometimes enough to eliminate the inoculum. (George N. Agrios, 2006)

Crop rotation

When one crop is grown year after year on the same area of land, pathogens that attack the crop have the opportunity to increase greatly, often to the point where further plantings of the same crop become economically impractical due to losses from disease. This build-up of disease problems can be avoided or greatly reduced by the practice of crop rotation (Singh *et al.*, 2012). Soil borne pathogens that infect plants can sometimes be reduced in soil by planting for 3 or 4 years crops belonging to species that are not attacked by particular pathogen.

Satisfactory control through crop rotation is possible with pathogens that are soil invaders i.e. survive only on living host. When the pathogen is soil inhabitant i.e. produces long lived spores, crop rotation is less effective (George N. Agrios, 2006).

Effect of crop rotation and fallowing options on bacterial wilt (BW) incidence (%)

Rogers *et al.,* conducted an experiment on crop rotation and it was found among 12 treatments crop rotation of Potato → (Maize+Crotalaria intercrop) → Clotoraria → Potato and Potato → (Beans+Crotalaria intercrop) → Crotalaria → Potato was found most effective.

Sanitation

Field sanitation is another important measure through cultural practices for preventing spread of plant disease and their management. Plant and plant parts are some of the best reservoirs of disease organisms.

The inoculum present on few plants in the field may multiply in the soil or on the plant and in due course of time may appear to cause epidemic in next season. Destroy or remove crop residues, culled fruits, unused seedbed plants, and prunings as soon as the crop is harvested or the cultural operation is completed.

Spacing

Spacing plants properly in the field prevents the creation of high humidity conditions on the plant surfaces and inhibit infection by certain pathogens.

Choice of fertilizers

A properly nourished plant is able to withstand or tolerate the attack of pathogens much better than a plant that has either nutrient deficiencies or excesses.

A nutrient-deficient plant will be stressed and therefore more prone to disease attack. Excessive fertilizer applications can also cause plants to be more susceptible to disease. Deficiency of calcium promotes wilt incidence of tomato. Heavy dose of N_2predisposes potato to late blight (Mehrotra, 2003).

Demerits

Improper implementation can incur great losses to farmer.

Cultural practices are labour intensive.

Complete control of diseases is not possible.

Success in controlling the disease is not guaranteed.

Physical methods

Physical agents are used in controlling plant disease such as temperature, dry air etc.

Heat treatment

Soil sterilization by heat

The soil is steam sterilized either in special containers or on green house benches, in which steam is piped into and is allowed to diffuse through soil.

At about 50˚c nematodes, some oomycetes and other water moulds are killed.

At 60 ˚& 70 ˚ c most plant pathogenic fungi and bacteria are killed.

At about 82 ˚ c most weeds, rest of plant pathogenic bacteria and viruses are killed.

Hot water treatment

It is used to treat certain seeds bulbs to kill any pathogen with which they are infected. The temperature and duration varies with crop (Chaube and Singh, 2005).

Hot air treatment

Treatment of certain storage organs with warm air removes the excess moisture from their surface and hastens the healing of wounds thus preventing their infection.

Several virus infected dormant plants are treated by hot air treatment at a temperature ranging from 35-54ºC for 8 h (Singh, 2012).

Control by radiations

Various type of electromagnetic radiations such as UV, X rays control post harvest diseases of vegetables by killing pathogen present on them.

Host-plant resistance

Host plant resistance is an important tool to control diseases of major vegetable crops.

Least expensive, easiest, safest and one of the most effective means of controlling plant diseases.

The use of resistant varieties is very much welcomed by farmers because it does not require additional cost and it is environment-friendly (Table 1).

Resistant varieties play an important role in controlling the losses caused by diseases in crop plants.

Resistant varieties lead to reduction in the cost of production resulting in increasing the cost benefit ratio.

Genetic resistance is the only solution of some diseases such as wilts, rusts, smuts, nematodes and bacterial blights.

Resistant varieties are non toxic.

Demerits

It is a long term process which takes 10-15 years to develop agronomically acceptable variety.

Breeding for disease resistance is an expensive method which requires adequate financing for a long period being a long term process.

In some cases, the resistant variety has lower yield and poor quality.

Chemical control

Chemicals are generally used to protect plant surfaces from infection or to eradicate a pathogen that has already infected a plant.

Chemical methods that eradicate the inoculum (Table 2)

Soil treatment with chemicals

Soil is treated with chemicals for control of nematodes and also for soil borne fungi such as *Fusarium, Verticillium* and bacteria.

Certain fungicides are applied to soil as dusts, liquid drenches, or granules to control diseases. Fugicides used for soil treatments include Metalaxyl, Diazoben, Pentachloronitrobenzene, Captanetc

Fumigation

The most promising method of controlling pathogens through the use of chemicals called fumigants. Some of them including Chloropicrin, Methyl bromide etc.

Nematicides used as soil fumigants as available as liquids, emulsifiable concentrates.

Disinfection of warehouses

Stored products can be protected from becoming infected by pathogens left over by first cleaning thoroughly the storage rooms and by removing and burning the debris. Walls and floors are washed with copper sulphate solution (1 pound in 5 gallon of water)

Demerits of chemical method

Drift of sprays and vapour during application can cause severe damage and residue problem in crops.

Residues in food for humans and feed for livestocks.

Ground water contamination by leached chemicals.

Resistance to the chemicals used can develop in target pathogens due to over and incorrect use of chemicals.

Biological control

Biological control is defined broadly as the "use of natural or modified organisms, genes, or gene products" to reduce the effects of pests and diseases. Biological control is the control of one organism by another (Beirner, 1967). This control may be expressed as either a longer population of the pest (DeBach, 1964) or as a restriction or prevention of the severity or incidence of pest damage without regard to the pest population (Cook and Baker, 1983).

Mode of action of biocontrol agents

Competition

Microorganism competes for space, minerals and organic nutrients to proliferate and survive in their natural habitats. This has been reported in both rhizosphere as well as phyllosphere. Competition has been suggested to a play a role in the biocontrol of species of Fusarium and Pythium by some strains of fluorescent pseudomonas

Antibiosis

Antibiosis is defined as antagonism mediated by specific or non – specific metabolites of microbial origin, by lytic agents, enzymes, volatile compounds or other toxic substances.

Antibiosis plays an important role in biological control. Antibiosis is a situation where the metabolites are secreted by underground parts of plants, soil microorganism, plant residues etc.

Mycoparasitism / Hyperparasitism

Mycoparasitism or hyperparasitism occurs when the antagonist invades the pathogens by secreting enzymes such as chitinases, celluloses, glucanases and other lytic enzymes.

Mycoparasitism is the phenomenon of one fungus being parasitic on another fungus. The parasiting fungus is called hyperparasite and the parasitized fungus as hypoparasite.

Biological methods that eradicate the inoculum (Table 3)

Suppressive soils

Several soil borne pathogens, such as Fusariumoxysporum, Phythium spp. develop well and cause severe diseases in some soils called as conducive soils. Where as they develop much less and cause much milder diseases in other soils called suppressive soils. In such soils, one or several microorganisms antagonistic to pathogen are present.

Table.1 Resistant varieties of vegetables

Crops	Varieties	Diseases	Source
Tomato	Pant Bahar HissarAnmol and Hissar Gaurav BWR-5 and BWR-1	Verticilium wilt Leaf curl virus Bacterial wilt	GBPUAT, Pantnagar HAU, Hissar IIHR, Bangalore
Brinjal	Pant Rituraj Pusa purple cluster PusaBhairav PusaSamrat	Bacterial wilt Bacterial wilt Phomopsis blight Bacterial wilt, Phomopsis blight & Shoot and fruit borer.	GBPUAT, Pantnagar IARI, Katrain IARI, Delhi GBPUAT, Pantnagar
Chilli	PusaJawala Punjab Lal	Leaf curl virus Leaf curl virus	IARI, New Delhi PAU, Ludhiana
Potato	KufriGirdhari	Late blight	Joseph *et al.*, 2011

Table.2 Chemicals used for control of various diseases

Crop	Disease	Causal organism	Treatment
Tomato	Fruit rot	*Phytophthora sp.*	Metalaxyl MZ 72 WP @0.3%
	Damping off	*Rhizoctonia spp.*	Mancozeb 75 WP (25g/10 l) Carbendazim 5WP (5 g/ 10 l)
Brinjal	Phomopsis blight and fruit rot	*Diaporthevexans*	Mancozeb 75 WP(0.3%) Zineb(0.2%)
Chilli	Anthracnose	*Colletotrichum capsici*	Hexaconazole 5EC (0.03%)
Potato	Late blight	*Phytophthora infestans*	Copper oxychloride 50WP @0.25%

Table.3 Bio control agents used to control various diseases

Source	Target Pathogen	Disease	Reference
Pseudomonas fluorescens	*Pythium* spp.	Damping off	Shanahan *et al*., 2002
Agrobacterium radiobacter	*Agrobacterium tumefaciens*	Crown gall	Kerr, 2000
Bacillus amyloliquefaciens	*Fusarium oxysporum*	Wilt	Koumoutsi *et al*., 2004
Lysobacter sp. strain	*Aphanomyces cochlioides*	Damping off	Islam *et al*., 2005
Trichoderma virens	*Rhizoctonia solani*	Root rots	Wilhite *et al*., 2001

Table.4

Treatments	Severity of alternaria leaf spot (%)	Severity of alternaria fruit rot (%)
T1- Staking	6.39	2.45
T2 -Mulching (mustard pod straw @ 4 kg/m²)	7.19	2.27
T3 -Removal of basal leaves	5.50	1.32
T4 -Sprays of mancozeb 75WP @ 2 g/L water followed by carbendazim 50 WP @ 0.5 g/L water	3.12	1.75
T5 -Staking + Mulching (mustard pod straw @ 4 kg/m²)	5.33	2.05
T6 -Staking + Removal of basal leaves	4.50	1.70
T7 -Staking + Sprays of mancozeb 75WP @ 2 g/L water followed by carbendazim 50 WP @ 0.5 g/L water	2.73	1.55
T8 -Mulching (mustard pod straw @ 4 kg/m²) + Removal of basal leaves	4.63	1.75
T9 -Mulching (mustard pod straw @ 4 kg/m²) + Sprays of mancozeb 75WP @ 2 g/L water followed by carbendazim 50 WP @ 0.5 g/L water	2.50	1.67
T10 -Removal of basal leaves + Sprays of mancozeb 75WP @ 2 g/L water followed by carbendazim 50 WP @ 0.5 g/L water	2.34	1.69
T11 -Staking + Removal of basal leaves + Sprays of mancozeb 75WP @ 2 g/L water followed by carbendazim 50 WP @ 0.5 g/L water	1.75	1.48
T12 -Staking + Removal of basal leaves + Mulching (mustard pod straw @ 4 kg/m²) +Sprays of mancozeb 75WP @ 2 g/L water followed by carbendazim 50 WP @ 0.5 g/L water	1.40	1.34
T13- Check/Control	10.81	3.75

Table.5

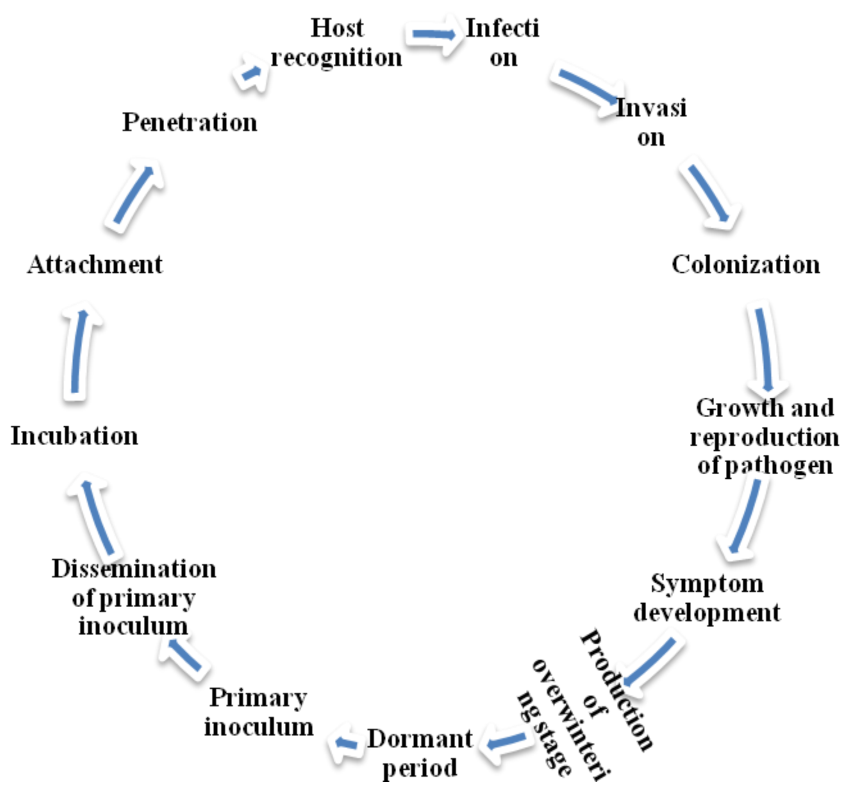
Treatments	Wilt incidence (%)	Disease reduction over control (%)	Yield (q/ha)
T1- Neem cake (20g/plant)	34.37	21.13	138.89
T2- *Trichoderma harzianum* (10g/l)	35.52	19.98	134.26
T3-*Puedomonas fluorescens* (10g/l)	32.77	22.73	174.07
T4- Streptocycline (0.3g/l) + copper oxychloride(3g/l)	36.10	19.40	170.37
T5- Neem cake(20g/plant)+ *T. harzianum* (10g/l)	35.22	20.28	109.57
T6- Neem cake(20g/plant) +*P. fluorescens* (10g/l)	34.60	20.90	111.42
T7-Neem cake(20g/plant) + Streptocycline (0.3g/l) + copper oxychloride(3g/l)	35.53	19.97	101.54
T8- *T. Harzianum*(10g/l) + *P. fluorescens* (10g/l)	34.72	20.78	122.22
T9- *T. harzianum*(10g/l)+ Streptocycline(0.3g/l) + copper oxychloride(3g/l)	33.34	22.16	109.26
T10- *P. Fluorescens*(10g/l) + Streptocycline(0.3g/l) + copperoxychloride(3g/l)	30.72	24.78	138.89
T11- Neem cake(20g/plant) + *T. harzianum* (10g/l)+*P. fluorescens* (10g/l) + Streptocycline (0.3g/l) + copper oxychloride (3g/l)	26.26	29.24	178.39
T12- Control	55.50	0.00	43.51

Table.6

Treatments	Disease controlled (%)	Yield (T/ ha)
T1: *Bacillus subtilis* (BS-0.25%)+*Trichoderma viride* (TV-0.7%)-3 spray	46.10	22.12
T2: *Bacillus subtilis* (BS-0.25%) + *Trichoderma viride* (TV-0.7%)- 2 spray	42.29	21.25
T3: *Bacillus subtilis* (BS-0.25%)+ *Trichoderma viride* (TV-0.7%)-1 spray	37.12	21.77
T4: *Bacillus subtilis*(BS-0.25%) +*Trichoderma viride* (TV-0.7%) - metalaxyl8+ mancozeb 64% WP (0.25) - *Bacillus subtilis* (B5-0.25%) +*Trichoderma viride* (TV-0.7%)	64.26	24.39
T5: *Bacillus subtilis* (BS-0.25%) +*Trichoderma viride* (TV-0.7%) before appearance of disease followed by cymoxanil 8% +mancozeb 64% WP (0.3%) at onset of late blight followed by one more spray of BS+ TV.	70.03	27.46
T6*: Bacillus subtilis* (BS-0.25%) +*Trichoderma viride* (TV-0.7%) - mancozeb 75% WP (0.2%) - *Bacillus subtilis*(B5-0.25%) +*Trichoderma viride* (TV-0.7%)	55.88	25.58

T7: *Bacillus subtilis* (BS-0.25%) +*Trichoderma viride* (TV-0.7%) - Neem oil based azadirechtin 0.15% (10.0%) - *Bacillus subtilis* (B5-0.25%) +*Trichoderma viride* (TV-0.7%)	42.74	24.96
T8: Mancozeb75% WP (0.2%) spray before appearance of disease followed by mancozeb75% WP (0.2%) at onset of late blight followed by one more spray of mancozeb75% WP (0.2%).	76.83	26.30
T9: *Bacillus subtilis* (BS-0.25%) - *Bacillus subtilis* (BS-0.25%) - *Bacillus subtilis* (BS-0.25%)	38.74	23.71
T10: *Trichoderma viride* (TV-0.7%) - *Trichoderma viride* (TV-0.7%) - *Trichoderma viride* (TV-0.7%)	39.65	22.63
T11:Control (without spray)	0.00	18.42

Fig.1



Such antagonists, through the antibiotics they produce, through lytic enzymes, through competition for food donot allow the pathogen to reach population to cause severe damage. Soil amended with soil containing strain of *Streptomyces spp.* antagonistic to *Streptomyces scabies*, cause of potato scab resulted in potato tubers free of potato scab

Through antagonistic microorganisms

The mycelium and resting spores of several fungi such as hythium, Phytophthora, Rhizoctonia are invaded and parasitized or lysed by several fungi. Among the most common mycoparasitic fungi are *Trichoderma harzianum. Trichoderma* *harzianum* paraitize mycelia of *Rhizoctonia* and *Sclerotium* to inhibit the growth of many oomycetes such as *Phythium*, *Phytophthora* and other fungi.

Merits of biocontrol agents

Biological control is less costly and cheaper than any other methods.

Biocontrol agents give protection to the crop throughout the crop period.

They do not cause toxicity to the plants.

Application of biocontrol agents is safer to the environment and to the person who applies them.

They multiply easily in the soil and leave no residual problem.

They are easy to manufacture.

It is harmless to human beings and animals (Environmentally safe.)

Demerits

Effective in laboratory and in green houses, not has been successful in field.

It is a slow process.

Level of control may not be sufficient.

Research costs are high and sometimes may not produce results.

It requires expert supervision.

It is difficult and expensive to develop and supply.

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 an ecologically and economically (Khokhar, 2014).

IDM is currently defined as: "a sustainable approach to managing diseases by combining biological, cultural, physical and chemical tools in a way that minimizes eco- nomic, health and environmental risks". (Khoury, 2010) OR Integrated disease management uses all suitable techniques that complement each other with the aim of keeping the disease below the threshold at which economic damage occurs (Table 4–6).

The basic objectives of any IDM program should be to achieve at least the following:

Reduce the possibility of introducing diseases into the crop

Avoid creating conditions suitable for disease establishment and spread

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.

WHY IDM?

Exclusive reliance on pesticides, fungicides and herbicides resulted in pesticide and herbicide -resistance, pest resurgence, residues and environmental pollution.

Dependency on chemicals for the management of various diseases is a great health hazard to the consumer.

IDM provides farmers with tools and strategies to minimize losses caused by diseases to sustainably maximize production.

Global population is on the rise and therefore so is food demand.

Advantages of IDM

Integrated approach integrates preventive and corrective measures to keep pathogen from causing significant problems, with minimum risk or hazard to human and desirable components of their environment. Some of the benefits of an integrated approach are as follows:

Promotes sound structures and healthy plants

Promotes the sustainable bio based disease management alternatives.

Reduces the environmental risk associated with management by encouraging the adoption of more ecologically benign control tactics

Reduces the potential for air and ground water contamination

Protects the non-target species through reduced impact of plant disease management activities.

Reduces the need for pesticides and fungicides by using several management methods

Reduces or eliminates issues related to pesticide residue

Reduces or eliminates re-entry interval restrictions

Decreases workers, tenants and public exposure to chemicals

Alleviates concern of the public about pest & pesticide related practices.

Maintains or increases the cost-effectiveness of disease management programs.

Solanaceous vegetables

Fusarium wilt of tomato

Causal organism: *Fusarium oxysporum f. sp. lycopersici*

Symptoms

Yellowing of the lower leaves appears first usually affecting the leaflets.

The affected leaves wilt and die, and the symptoms continue to appear on younger leaves.

Sometimes browning of vascular system may be seen in cross section of lower stem.

The plant as a whole is stunted and permanent wilting of leaves leads to their death

Effect of various management practices on diseases of Tomato variety (SH-1)

Ali Anwar *et al.*, conducted an experiment and it was found among 12 treatments, Staking + Removal of basal leaves + Mulching (mustard pod straw @ 4 kg/m^2) +Sprays of mancozeb 75WP @ 2 g/L water followed by carbendazim 50 WP @ 0.5 g/L water was most effective treatment.

Bacterial wilt of brinjal

Causal organism: *Ralstonia solanacearum*

Symptoms

Symptoms begin as dropping of lower leaves, which soon advance resulting in the wilting of whole plant.

The wilted leaves later die and turn brown. The stem of such plants, when split open, show dark brown discoloration of vascular bundles near soil line.

Integrated management of bacterial wilt of brinjal caused by *R. solanacearum*

Revathi RM *et al.*, conducted an experiment and it was found among 12 treatments, - Neem cake (20g/plant) + *T. harzianum* (10g/l)+*P. fluorescens* (10g/l)+ Streptocycline (0.3g/l) + copper oxychloride (3g/l) treatment was most effective.

Late blight of potato

Casual organism: *Alternaria solani*

Symptoms

Irregular brown spots with concentric rings are formed on leaves.

The disease first appears as spots on the leaflets.

They are circular to angular, dark brown to black in colour.

Integrated management of late blight of potato (MehiLal *et al.*, 2017)

MehiLal *et al., conducted an experiment, it was found among 11 treatments, Bacillus subtilis* (BS-0.25%) +*Trichoderma viride* (TV-0.7%) before appearance of disease followed by cymoxanil 8% +mancozeb 64% WP (0.3%) at onset of late blight followed by one more spray of BS+ TV treatment was found most effective.

Constraints in integrated disease management

Lack of information on IDM among farmers and extension worker. Lack of training on IDM. Lack of funds for training farmers and extension workers on the use of IDM.

Some farmers feel it is risky to adopt IDM compared to use of pesticides alone.

Pesticides companies use mass media like television and newspapers for popularizing their products through attractive advertisements.

Farmers are addicted to subsidy and they always look for some financial support for adopting these methods.

Bio-pesticides, bio control agents and other IDM components are not readily available.

Cultural practices are basic but eco-friendly way to minimize diseases.

Chemicals must be used at recommended rates and application frequencies. Besides selection of the most efficacious material, equipment must be properly calibrated and attention must be paid to the appropriate application technique.

Biological approach may provide a better alternative, as activity of natural antagonists can then be encouraged.

The success and sustainability of IDM greatly depends on their involvement in helping to generate locally specific techniques and solutions suitable for their particular farming systems and integrating control components that are ecologically sound and readily available to them. Training and awareness of farmers, disease survey teams, agricultural development officers, extension agents and policy makers remains to be an important factor for the successful implementation of IDM strategies.

All direct stakeholders including farmers, extension workers, and local crop protection technicians should have a practical understanding of the ecology, etiology and epidemiology of the major diseases of the crop.

References

Abawi, G.S., 1989. Root rots. In: Schwartz, H.F., Pastor Corrales, M.A. (Eds.), Bean Production in the Tropics. *Centro Inter nacional de Agricultura Tropical, Cali, Colombia*, p. 105 157.

Adikshita and Sharma, M. 2017. Integrated approaches for management of anugular leaf spot of French bean. *International Journal of Science, Environment*, 6:2.

Agrios, G.N. 2006. Plant pathology (Fifth Edition) pp. 254-286

Anwar, A., Bhat, M., Mughal, M.N, Mir, G.H., and Ambaradar, V.K. 2017. Integrated Management of Major Fungal Diseases of Tomato in Kashmir Valley, India. *International Journal of Current Microbiology and Applied Sciences* 6p. 2454-2458

Baker, K. F., and R. J. Cook. 2012. Biological Control of Plant Pathogens, *W. H. Freeman and Co, San Francisco, California*. 433 p.

Beirner, B. P. 1967. Biological control and its potential. World Rev. Pest Control 6:7-20.

Bhat, M.H. 2013. Status and Integrated management of Ascochyta Blight of Field pea (*Pisum sativum* L.). MSc. thesis, SKUAT-K.

Chaube, H.S. and Singh, U.S. 1990. Plant Diseases Management: Principles and Practices, C.R.C. Press, US, P. 319.

Cook, R. J., and K. F. Baker. 2002. The Nature and Practice of Biological Control of Plant Pathogens. *Amer. Phytopathol. Soc., St. Paul, Minnesota*. 539 p.

De Bach, P., ed. 1964. Biological Control of Insect Pests and Weeds. Reinhold, New York, New York. 844 p.

Gupta, H., Singh, B.P. and Mohan, J. 2004. Bio-control of late blight of potato. *Potato Journal*. 31:39-42.

Gupta, R.C and Gupta, R.P.2013.Effect of Integrated disease management practices on disease incidence and bulb yield of onion (*Allium cepa* L.). *SAARC Journal of Agriculture*, 11:49-59

Hamid, A. 2007. Biological Management of Root Rot of Pea (*Pisum sativum L*.). MSc. thesis, SKUAST-K.

Khanna, M.R. 2014. Integrated Management of Purple Blotch Disease of onion. Msc. thesis, SKUAST-K.

Khokhar, M.K., and Gupta, R. 2014.Integrated disease management. *Journal of popular kheti*, 2: 87-91.

Khoury, W.E., and Makkouk, k. 2010. Integrated plant disease management in developing countries. *Journal of plant pathology*9:35-42.

Kumar, V., Ram, R.B., Meena, M.L., Shukla, V., and Singh, C. 2013. Integrated disease management through organic farming in vegetable crops in India: A sustainable tool. *Asian Academic Research Journal of Multidisciplinary* 1:4-12

Lal, M., Yadav, S., Sharma, S., Singh, B.P., and Kaushik, S.K, 2017. Integrated management of late blight of potato. *Journal of Applied and Natural Science*, 9: 1821 -1824

Mahavi. M., Kumar, C.P.C., Reddy, D.R.R. and Singh, T.V.K.2006.Integrated Management of wilt of chilli incited by *Fusarium Solani*. *Indian Journel of Plant Protection*, 34:225-228

Majeed, M, 2014. Biological Management of Damping-off Disease of Chilli (*Capsicum annum* L.) Msc. thesis, SKUAST-K.

Mehrotra, R.S. 2003. Plant Pathology. IInd

Ed. Tata McGraw Hill Publication Company Ltd. New Delhi. p. 771.

Mishra, P.K., Saha, S., Singh, R.P., Singh, A., and Rai, A.B. 2012. Integrated approach for the management of blight of cauliflower. *International Journal of Agriculture Environment Biotechnology*. 5: 373-376

Morton, V. and Staub, T. 2008. A Short History of Fungicides. Online, APSnet Features. doi: 10.1094/APSnetFeature-2008-0308.

Muzaffar, M. 2018. Studies on the Management of Wilt Complex Disease of Chilli (*Capsicum annum L*.) in Kashmir. MSc. thesis, SKUAST-K.

Pandey, A.K., Sain, S.K., and Singh, P.2016. A Perspective on Integrated Disease Management in Agriculture. *Research journal Bio Bulletin*2: 13-29

Rather, T.R., Razdan, V.K., Tewari, A.K., Shanaz, E., Bhat, Z.A., Hassan, M.G and Wani, T.A. 2012. Integrated Management of Wilt Complex Disease in Bell Pepper (*Capsicum annuum* L.) *Journal of Agricultural Science* 4:7

RM, R., H, N., Adivapper, N., and Naik, S.M. 2017. Integrated management of bacterial wilt of brinjal incited by *Ralstonia solanacearum. Journal of pharmacognosy and phytochemistry. 7: 271-273.*

Sharma, P., Sharma, S.R., Sain., S.K and Dhandapani, A. 2006. Integrated management of major diseases of cauliflower (*Brassica oleraceavar botrytis subvar cauliflora*). *Indian Journal of Agricultural Sciences*76 : 726-31

Singh, V.K., and Chawla, S. 2012. Cultural Practices: An Eco-friendly Innovative Approach in Plant Disease Management.

Singh, Vaibhav. K. 2008. Studies on Population Biology, Epidemiology and Management of Late Blight of Potato caused by *Phytophthora infestans* (Mont.) de Bary. Ph.D. Thesis. G.B.P.U.A.T., Pantnagar.

Stover, R.H. 1962. Fusarium wilt of Panama diseases of bananas and other Musa species. Phytopathological Paper No. 4, Commonwealth Mycological Institute, Kew, UK.

Wani, F.A. 2007. Integrated management of chilli wilt [*Fusarium pallidoroseum* (cooke) Sacc.] in Kashmir. Ph. D thesis, SKUAST-K.