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Diseases of Major Bulbous Vegetable Crops and Their Management

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Authors' contributions

This work was carried out in collaboration among all authors. Author FR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors NM and DS managed the analyses of the study. Author SH managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Onion and garlic are the major bulbous vegetable crops grown throughout the world. They are commercially used in the form of spice, vegetable or medicine. India ranks second in world production of both onion and garlic. These are mostly grown in states of Maharastra, Uttar Pradesh, Orissa, Gujrat, Haryana, Jammu and Kashmir and Karnataka. These bulbous crops are attacked by various pests and diseases at different growth stages causing considerable losses in yield, besides reducing the export potential. The continuous use of chemicals and pesticides pose severe threats to both environment and mankind, besides enhancing insect resistance to chemicals. It also disturbs microbial diversity which is an essential part of an ecosystem. This has created a new dimension in research for biological control and integrated approach for insect pest and disease control. Essential diseases and pests affecting major bulbous vegetable crops and their management are summarised in this manuscript.

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Keywords: Bulbous vegetables; production; diseases; pests; management.

1. INTRODUCTION

Onion and garlic are the most essential bulb crops cultivated throughout the world and used both as a vegetable and spice in many ways. India occupies second position in an area as well as a production of onion, producing 1.6 million MT annually after China [1]; however, the productivity and per capita availability are quite low as compared to other countries.The productivity of onion in India is 14.35 t/ha which is at least 5 times lesser as compared to republic of Korea (66.16 t/ha), about 4 times less than USA (56.13 t/ha), Spain (55.21 t/ha), Netherland (51.64 t/ha) and Myanmar (46.21 t/ha) [2].Several factors are responsible for the low productivity of these crops, of which diseases and insect pests are most essential and cause considerable damage and should be taken care of. A number of post-harvest management practices for different onion and garlic varieties have been standardized. V. Anbukkarasi et al. [3] reported that during the off-season the efficient storage facility plays an important role for the consumers as well as for the producers which ultimately prevents serious losses due to rotting and sprouting. Plant protection measures for managing diseases and insect pests have also been developed. There is, however, a great scope for boosting the production by minimizing the losses due to various biotic stresses.

The major diseases of onion and garlic have been elaborated with an emphasis on those for which effective disease management systems have been put into practice.

2. BASAL ROT

Fusarium oxysporum f.sp. *cepae.*

2.1 Symptoms

The leaves turn yellow and then dry up slowly. The affected plant shows drying of leaf tip downwards. There is complete drying of the foliage. The affected bulb shows rotting symptoms with whitish mouldy growth on the scale. This disease can begin in the field and continue in storage [4,5,6,7,8]

2.2 Pathogen Characteristics

The fungus produces many chlamydospores, which are thick walled resting spores and microconidia which are one celled and thin walled.

2.3 Mode of Spread and Survival

The pathogen is soil-borne and the optimum temperatures for disease development are 28 - 32°C. Infection occurs through the root either directly or through wounds.

2.4 Management

Growers must follow crop rotation, and harvested bulbs must be thoroughly cured, by shade drying in a field for 10-15 days, to reduce potential storage losses. Onions are very sensitive to low soil copper levels. To optimise crop production and disease susceptibility, additional soil copper fertility may be needed especially on mucky and sandy soils. Soil drenching with Copper oxychloride @ 0.25% is recommended.

3. DOWNY MILDEW: *Peronospora destructor*

3.1 Symptoms

White downy growth appears on the surface of the leaves. Finally the infected leaves are dried up.

3.2 Pathogen Characteristics

The sporangiospores are non-septate, long and swollen at the base.Sporangia are pyriform to fusiform, attached to the sterigmata by their pointed end.These sporangia germinate by one or two germ tubes.The coenocytic mycelium is intercellular with filamentous haustoria. Oogonia are formed in the intercellular spaces.

3.3 Mode of Spread and Survival

The fungus attacks the seed stalks in a seed crop and has been found on and in seed as mycelium.The main sources of perennation are the diseased bulbs, containing oospores, used for propagation. If infected bulbs are planted, the fungus grows up with the foliage, produces sporangia and then spread to healthy ones.

3.4 Disease Cycle

3.4.1 Dormant period

It is believed that the DM fungus overwinters primarily as mycelium in infected onions that

remain in onion fields or in nearby cull piles. The pathogen also can overwinter in perennial varieties of onion in home gardens. The fungal spores that persist in the soil may directly infect the roots of young onion plants. These plants become systemically infected and serve as a source for infection in commercial onion fields.

3.4.2 Primary spread

Under favourable environmental conditions, the overwintering fungal mycelium in systemically infected plants produces spores and after dissemination through the air, these spores infect the leaves of onion plants in commercial fields. Spores are formed at night when high humidity and temperatures of 4–25°C persists, with an optimal temperature of 13°C. The spores mature early in the morning and are disseminated during the day. Spores remain viable for about 4 days. Germination occurs in free water from 1–28°C with an optimal range of 7–16°C. Rain is not needed for infection if heavy dews occur continuously during the night and morning hours.

3.4.3 Secondary spread

The mycelium of DM in leaves of infected plants produces a new crop of spores called conidia in cycles of approximately 11–15 days. As the upper portions of a leaf are killed, the fungus infects the next lower part of the leaf in each successive cycle of spore formation. Such sequences can be repeated several times until the leaf may be completely killed. These repeated cycles of spore formation can result in severe and continued epidemics if disease favourable environmental conditions persists.

3.5 Management

Three spraying with Mancozeb 0.2% is effective. Spraying should be started 20 days after transplanting and repeated at 10-12 days interval.

4. LEAF BLIGHT (BLAST)*: Botrytis* spp.

4.1 Symptoms

Botrytis is the major disease occurring in cool climatic conditions. Light infections do not affect yields but heavy infections causing major yield reductions can occur. Hundreds of white specks are seen on the foliage which spreads very rapidly.

4.2 Pathogen Characteristics

Botrytis is characterized by its conidiophores giving an appearance of grape bunch. The conidiophores are long, erect and branches irregularly or dichotomously. They are dark and septate. The terminal cells swell to produce sporogenous ampullae. On each ampulla numerous conidia arise simultaneously on short lenticles. The conidia are hyaline or tinted, aseptate and globose to ovoid.

4.3 Dormant Period

The Botrytis leaf blight pathogen over winters as sclerotic (compact mass of fungi capable of surviving unfavorable environmental conditions). These are produced on infected onion bulbs left in cull piles, on mother bulbs, stored for seed production and on bulbs left in the field. Sclerotic also over winter directly in the soil and on leaves that persist as debris in commercial onion fields. The sclerotia are formed on infected leaves and the necks and upper portions of bulbs before or after harvest. Infected leaves may be raked or washed together and persist as leaf tissue debris in which many sclerotic can be found. Sclerotic in the soil result from the disintegration and decay of infected leaves on which sclerotic were formed.

4.4 Primary Spread

Sclerotia on leaf debris produce conidia and ascospores (sexual spores) that infect leaves of onion plants. Because ascospores are the result of sexual reproduction, they may serve as the source of new strains of the pathogen that are tolerant to fungicides. The ability of sclerotic to germinate and produce conidia repeatedly (up to four times) results in the production of conidia over an extended period of time. Sclerotic on the bulbs of volunteer onions produce conidia that infect either leaves of the same plant or those of onion plants in commercial fields. In the absence of seed fields and cull piles, it provide the primary source of inoculum for outbreaks of Botrytis leaf blight in commercial onion fields.

4.5 Secondary Spread

The dense, tangled growth of leaves that develop from bulbs in cull piles provides conditions (little air movement and high relative humidity) that are favorable for subsequent production of spores on dead leaf tissue. This results in secondary cycles

of infection in the cull piles. Conidia are blown from the seed fields and cull piles to commercial bulb production fields and the disease cycles continue .Leaves of onion plants in commercial fields can be infected by conidia that develop from sclerotic in the soil.These infected leaves serve as secondary sources of inoculums, once conidia are produced on the dead leaf tissue. Leaves of onion plants grown for commercial production are repeatedly infected, and these serve as the source of inoculum for infecting new leaves throughout the growing season.

4.6 Management

Bulb treatment with Captan /Thiram @ 0.25% is desired. Spraying of Maneb or Mancozeb or Chlorothalonil is recommended. Fungicides may be applied every 5 - 7 days for disease control.

5. PYTHIUM ROOT ROT: *Pythium aphanidermatum*, *P. debaryanum* AND *P. ultimum*

5.1 Symptoms

This disease causes seed rotting and pre-emergence damping off. The disease appears in circular patches in the field. If disease occurs prior to seed germination, it causes gappiness. The seeds or seed materials are killed before their establishment. The disease also occurs after establishment of the crop *i.e* after 15 to 30 days of sowing or planting. This stage is called post-emergence damping off. At later stage of infection, it causes stunting of the plant and rotting of the roots.

5.2 Pathogen Characteristics

Pythium aphanidermatum.

5.3 Epidemiology

The fungus is mainly soil borne. The disease is favoured by ill drained conditions in the field due to stagnation of water. High soil moisture or continuous rain may favour rapid development of the disease.

5.4 Management

Seed treatment with Thiram or Captan @ 4 g/kg or dipping of bulbs in Thiram solution 0.25% is recommended.

6. SMUT: *Urocystis cepulae*

6.1 Symptoms

Black smut sori are seen at the base of the leaves and leaf surface. Black powdery mass is seen after rupturing of sorus wall.

6.2 Pathogen Characteristics

The sori of *Urocystis cepulae* contain dark coloured and powdery spore masses. These spores are found in permentant balls. Each ball consists of an enveloping cortex of tined, sterile, bladder like cells with one or two central dark coloured thick walled chlamydospores. The spores germinate by means of short promycelium while still in the ball.

6.3 Mode of Spread and Survival

The fungus remains viable for 15 years in infected soil by means of spore balls. It persists in soil as a saprophyte. Onion bulbs and onion transplants are important means of widespread distribution of the fungus. Implements also help in the spread. Wind borne soil and surface drainage water are important means of local dissemination.

6.4 Management

Seed treatment with Thiram or Captan @ 4g/kg. The bulbs may be dipped in Thiram solution 0.25%.

7. WHITE ROT: *Sclerotium cepivorum*

7.1 Symptoms

The leaves become yellow and show die-back symptoms .The base of the bulb is covered with a white or grey fungal growth. Later, numerous small black spherical sclerotia are produced. Finally,the bulb completely rots.

7.2 Mode of Spread and Survival

The disease is more severe in warm summers or during warm spell in autumn or spring. Sclerotia persist in soil for eight years. The primary inoculum consists of spherical small black sclerotia produced in infested fissure during previous years. Scelerotia are transported from field to field by flood water.

7.3 Disease Cycle

The sclerotia on the decaying host will remain dormant until a host plant's root exudates stimulate germination. Cool weather is important for germination of sclerotia and hyphal growth. Mycelium grow through the soil,encounters host roots and form appresoria which penetrates the host. Mycelium can grow outwards from the roots of one plant to the roots of a neighboring plant.Sclerotia are formed on the decaying host tissue, and once the host tissue completely decays the sclerotia are free in soil. If the bulbs survive long enought to be placed into storage, the pathogen may continue to decay the bulbs if there is high humidity and low temperatures

7.4 Management

Crop rotation and clean seed are the only effective control. Heavy manuring with organic manures reduces the disease in the crop. Seed dressing with Benomyl, Carbendazim or Thiophanate-methyl (100 to 150 g/kg seed) gives effective control.

8. PURPLE BLOTCH: *Alternaria porri*

8.1 Symptoms

This disease occurs mainly at the top of the leaves as whitish minute dots with irregular chlorotic areas on tip portion. Circular to oblong concentric black velvety rings appear in the chlorotic area. The lesions later develop towards the base of the leaf. The spots join together and spread quickly to the entire leaf area. The leaves gradually die from the tip downwards.

8.2 Pathogen Characteristics

Alternaria porri mycelium is branched, coloured and septate. Conidiophores arise singly or in groups. They are straight or flexuous, sometimes geniculate.

8.3 Management

Disease free bulb should be selected for planting. Seeds should be treated with Thiram @ 4 g/kg seed. The field should be well drained. Three foliar sprayings with Copper oxychloride 0.25% or Chlorothalonil 0.2% or Zineb 0.2% or Mancozeb 0.2% should be practiced.

9. NECK ROT: *Botrytis allii, B. squamosa* AND *B. cinerea*

Symptoms usually appear after harvest, although infections originate in the field. Greatest epidemic development occurs when cool (50° to 75°F), moist weather prevails for some days before or during harvest. Symptoms are first seen as a softening of the tissues around the neck of the bulb, or more rarely, at a wound. A definite margin separates diseased and healthy tissues. Infected tissues become sunken, soft, and appear brownish to grayish in color, as if they had been cooked. These symptoms progress gradually to the base of the bulb. Then the entire bulb may become mummified. Hard, irregularly shaped kernel-like bodies, sclerotia, may form between scales, especially at the neck region.

9.1 Mode of Spread and Survival

The fungi that cause neck rot survive in winter on previously infected onion debris in the soil, in cull piles and refuse dumps. Water may be source of pathogen; and could be transferred from water to the vegetables [9,10]. Initial symptoms include water soaked areas on the outer surface of scales. Later, a green to blue green, powdery mold may develop on the surface of the lesions. Infected areas of fleshy scales are tan or gray when cut. In advanced stages, infected bulbs may disintegrate into a watery rot. Many species of *Penicillium* can cause blue mold. These fungi are common saprophytes on plant debris and senescent plant tissue.

9.2 Pathogen Characteristics

Penicillium produces an enormous number of spores on a broom like conidiophore. Some of these spores are in the air at all times and are carried to long distances by wind. In moist air they germinate readily. Symptoms develop slowly on the bulbs.

9.3 Mode of Spread and Survival

Invasion of onion bulbs and garlic is usually through wounds, bruises, or uncured neck tissue. Once inside the bulb, the mycelium grows through the fleshy scales, eventually sporulating profusely on the surface of lesions and wounds. Optimum conditions include moderate temperatures 70° to 77°F (21° to 25°C) and high relative humidity.

9.4 Black Mould

Aspegillus niger Infected bulbs are discolored black around the neck, and affected scales shrivel. Masses of powdery black spores are arranged as streaks along veins on and between outer dry scales. Infection may advance from the neck into the central fleshy scales. In advanced disease stages, the entire bulb surface turns black, and secondary bacterial soft rot may make the bulb soft and mushy. No external symptoms may be found with some bulbs. *Aspergillus niger* is able to produce mycotoxin which reduces the quality and quantity of food products and feed-stuff which is a potent hepatic- carcinogen in humans and animals.[11,12,13,14,]

9.5 Management

Seeds should be treated with Thiram @ 4 g/kg seed. The field should be well drained. Three foliar sprayings with Copper oxychloride 0.25% or Chlorothalonil 0.2% or Zineb 0.2% or Mancozeb 0.2% should be carried out. Growers must follow crop rotation and harvested bulbs must be thoroughly cured to reduce potential storage losses. Soil drenching with Copper oxychloride 0.25%

10. CONCLUSION

A major problem in the production, storage and processing of vegetables is caused by diseases. The farmers are nowadays facing heavy yield losses both in quality and quantity of vegetable crops due to damage as a result of various diseases . These diseases develop through soil-borne, infections and by insect as a vectors. The present review gives inclusive information regarding various pathological aspects of the fungal, bacterial and other diseases, their causes and management strategies accomplished on them. Many studies have been carried out with respect to occurrence, causal organisms, severity, losses, Pathogenicity and disease management. This review may help the future researchers to devise a concrete strategy for evaluating different pathological aspects and management of pre and post harvest diseases of vegetables. However, further study is needed to reveal all the other recent reports about various pathological aspects on the diseases of vegetables and management strategies opted for diseases

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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