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Fungal Biotic Stresses in Plants and Its Control Strategy

Faisal Hussain and Farzana Usman

Abstract

Vegetable and fruit are economically very important and valuable crops throughout the world. According to Pakistan Agriculture Research Council (PARC) the same report, Pakistan was the fifth largest exporter in the world, but according to there is continuous decline in the production of fruit and vegetable in Pakistan. The reasons for this reduction are various and many but the major threat in yield production is various pests and pathogens which cause considerable losses every year. Major insects which attack on crop fields are aphids, mites, thrips, etc.; besides pests, different pathogens also cause various diseases in field crop and reduce yield of the plant, for example, fungi, viruses, bacteria, and nematodes. Among other pathogens, the fungal diseases are more destructive than diseases cause by other pathogens.

Keywords: fungi, phytopathogens, vegetables, losses, yield

1. Introduction

Commonly fungal diseases cause more damage than diseases cause by other pathogens. Several fungi cause various diseases in different crop fields and plants (Table 1). Sometime these fungi can cause similar symptoms and confused to

Crop stage	Common fungal diseases	Causal agent
<i>Vegetative stage</i>		
Seedling	Damping off, <i>Phytophthora</i> blight, <i>Fusarium</i> wilt	<i>Pythium</i> spp., <i>Phytophthora</i> sp., <i>Fusarium oxysporum</i>
After transplantation	Frog eye leaf spot, damping off, <i>Fusarium</i> wilt	<i>Cercospora capsici</i> , <i>Pythium</i> spp., <i>Fusarium oxysporum</i>
Root diseases	<i>Phytophthora</i> root rot, <i>Verticillium</i> wilt, <i>Rhizoctonia</i> root rot	<i>Phytophthora capsici</i> , <i>Verticillium</i> sp., <i>Rhizoctonia solani</i>
<i>Reproductive stage</i>		
Flowering	Powdery mildew	<i>Leveillula taurica</i>
Fruiting	<i>Aspergillus</i> , anthracnose, powdery mildew, <i>Phytophthora</i> pod rot, black mold	<i>Aspergillus</i> spp., <i>Colletotrichum</i> sp., <i>Leveillula taurica</i> , <i>Phytophthora capsici</i> , <i>Alternaria</i> spp.

Table 1. Fungal diseases and their causal agents attacking on chili plant at different crop stages.

Regions	Subregions	Major areas in Pakistan
<i>Saharo-Sindian</i>		Lower Sindh, some areas of upper Sindh, Central and Southern Punjab, Southern Balochistan and KPK plains, Rawalpindi, Islamabad
<i>Irano-Turanian</i>	a. Western subregions b. Eastern subregions or Central Asia	Waziristan and North Baluchistan Upper portion of northern areas, Baltistan, Chitral
<i>Sino-Japanese</i>		Kashmir, KPK, Der, Swat, Muzaffarabad, Hazaras
<i>Indian</i>		East and west of river Jhelum, Lahore

Table 2.
Major chili-producing phytogeographical regions of Pakistan.

one another. There are some preharvesting fungal diseases such as *Aspergillus*, *Alternaria*, anthracnose, *Cercospora* (frog-eye) leaf spot, charcoal rot, *Choanephora* blight (wet rot), damping-off, root-rot, downy mildew, *Fusarium* stem rot, *Fusarium* wilt, gray leaf spot, gray mold, *Phytophthora* blight, powdery mildew, Southern blight, *Verticillium* wilt, and white mold that are grown in different crops.

The vegetable and cereal crop are recorded about the entire region and areas of Pakistan. So there are no clear-cut boundaries between each region and intermingling of crop fields occurs. Pakistan has four major phytogeographical regions [1, 2]. Major floristic zones are summarized in **Table 2**.

2. Major fungal diseases causing loss of crops

Commonly fungal diseases cause more damage than diseases caused by other pathogens. Several fungi caused various diseases in field crops. Some major fungal diseases which are responsible for heavy loss to the field crops are as follows:

2.1 *Alternaria* spp.

Genus *Alternaria* is considered as seed-borne fungi, widespread, and highly cause of decline that usually infects chili plants. The loss of fruit yield has been recorded to be up to 100% under certain environment conditions [3]. The disease is characterized by fairly firm, superficial lesions which often occur on berries near the pedicel. Lesions are tan at first, become dark brown to black with age, and remain localized. Under humid conditions provided by cold transit, fluffy gray tufts of fungus often occur on rachis and pedicels, occasionally without causing visible lesions [4]. Symptoms of *Alternaria* begin as water-soaked, gray lesion on either the side or blossom-end of the fruit [5]. As the lesion progresses, they darken and become covered with spores. Internal necrosis and mycelial growth occur on the seeds, placenta, and pericarp but are not noticed until the harvesting [6]. Infection can occur through the flowers or insect injury, mechanical damage, chilling injury, sunburn, or blossom-end rot [6–9].

2.2 Anthracnose/dieback/fruit rot (*Colletotrichum* spp.)

Anthracnose or dieback and fruit rot are caused by *Colletotrichum* sp. [10–12]. The fruit-rot diseases the diseases of crops which belong to the tropical regions has been reported heavy damage. It is remarked as major harmful disease of vegetable

crop [13]. Anthracnose also caused by *Colletotrichum* spp. is a major problem of ripened fruit (Hence, it is also called as ripe fruit rot.), occurs worldwide wherever cereal and other crops are grown [14], is severely infected by anthracnose which may cause yield losses up to 50% [15]. It is a seed-borne fungus. It produces dark spot, water-soaked lesions that rapidly expand. In some cases, the lesions are brown and then turn black from the formation of setae and sclerotia [16]. Infections spread rapidly during periods of excess irrigation or rain on immature pods.

2.3 *Aspergillus* spp.

Several fungi may be present on fruit after the postharvest and storage due to the relative humidity is not controlled during the storage process [17]. There are a number of *Aspergillus* sp. recorded in different crop-growing areas of Pakistan including *Aspergillus flavus*, *A. niger*, *A. fumigates*, etc. Several fruit and vegetables are reported to be contaminated with molds and their toxic metabolites, and *Aspergillus flavus* is the predominant mold on collected samples in several cases [18–22]. Aflatoxins are chemically classified in secondary metabolite which is mostly produced by *Aspergillus flavus*, *A. bombycis*, *A. nomius*, *A. parasiticus*, and *A. tamarii* in chili [23–25].

2.4 Damping off (*Pythium* spp.)

Damping off is a very common disease in nursery seedling beds showing irregular patches. *Pythium* spp. cause this disease which is basically a soil-borne fungus. This disease is more severe in soils with poor drainage.

2.5 Powdery mildew (*Leveillula taurica*)

Powdery mildew is caused by *Leveillula taurica* (asexual stage of fungus). It usually occurs in warm climates (65–95°F), both dry and humid weather. It affects the lower leaf surface, where the lesions are covered with a white to gray powdery growth. Disease progresses from the older leaves to younger leaves, and defoliation is a prominent symptom which reduces the size and number of fruits.

2.6 *Fusarium* wilt (*Fusarium oxysporum*)

Fusarium sp. is a soil-borne fungus and can survive for several years. It is usually grown in wet soil and high temperature. It causes wilting of the plant and upward and inward rolling of the leaves, and as a result leaves turn yellow and die. It causes discoloration of the vascular system of plant, particularly in the lower stem and roots.

2.7 *Cercospora* leaf spot (frog eye) (*Cercospora* spp.)

The leaf lesions due to this disease are circular about 1 cm in diameter with brown border and light gray centers. Lesions are also appearing on stem, petioles, and peduncles. It is a seed-borne fungus. It is also spread by water, wind, and leaf to leaf contact. Severely infected leaves turn yellow and drop from the plant. The fungus usually survives from one season to another on crop debris.

2.8 *Phytophthora* blight (*Phytophthora* spp.)

This disease is also known as *Phytophthora* root rot. Fungus affected all parts of plant. It commonly creates problem when soils are excessively wet either from over

irrigation, heavy rain, or both. The most common symptom is a stem or collar rot by sudden wilting without foliar yellowing.

3. Common recommended cultural control

Integration of chemicals and biotic agents along with resistance for managing plant disease has been considered as a novel approach [26]. The studies of chemical and biological management are valuable to comprehend and understand biodiversity. In general, isolating, identifying, and determining structures of new metabolites are fundamental to reveal their chemical potential, a first step to use, conserve, and protect them [27]. Several attempts to control root-rot fungi could be amended including disinfestations of the soil and planting material with fungicidal chemicals, crop rotation with nonhosts of the fungus, and use of resistant cultivars [28–30].

- Crop rotation.
- Discard the weeds from the crop.
- Disease-resistant variety should be used.
- Same family crops should not be planted in the same field more than once every 3 years.
- Excessive irrigation prior to seedling emergence should be avoided and, after establishment, water should not stand in the field for more than 12 hours.
- Before sowing, the seed should be dried by artificial (machine) method or sunlight method.

4. Chemical control

- Disinfect containers, seed trays, and propagators thoroughly. Dettol is good but tea-tree oil and camomile tea make good alternatives and are safe to use on plants.
- The strobilurin fungicides azoxystrobin (Quadris), trifloxystrobin (Flint), and pyraclostrobin (Cabrio) have been labeled for the control of anthracnose fungus in chili crop.
- Spray twice at 10–15 days interval with 2.5 g mancozeb or 1 g carbendazim/lit of water for the control of *Cercospora* leaf spot.
- Soil sterilization by drenching the soil 4” deep with formaldehyde diluted 50 times with water or with some other effective chemical soil sterilant.
- Soil drenching with 1% Bordeaux mixture or 3 g copper oxychloride like Blue Copper per liter of water at 12 and 20 days after sowing is also useful.
- Seed treatment with 3 g captan or thiram per kg seed.

- Seed treatment with 4 g *Trichoderma viride* formulation combined with 6 g metalaxyl is highly effective.
- Foliar spraying with captafol at 0.2% followed by copper oxychloride at 0.25% and carbendazim at 0.1% during the start of anthracnose disease.

5. Conclusion

The yield of fruit and vegetable is reducing gradually every year due to the presence of different pests and pathogens which cause heavy losses. There is a need to find out different effective methods for the control of these diseases and reduce field crop losses. Due to the use of improper methods of disease management, different fungi particularly *Aspergillus* sp. grow on fruits and produce toxic compound (mycotoxins), which are harmful for human health. Due to the presence of high percentage (%) of these mycotoxins in different vegetables and fruit products, European Union countries and Japan governments have banned import of consignment products in their countries. It is need to improve disease management methods to prevent the growth of fungi during processing, marketing, and transportation and reduce the percentage (%) of mycotoxins in our products which increase our products' export, and thus country will get more foreign exchange.

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