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Aerial diseases and their management in *Cuminum cyminum* L.: A review

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Abstract

Cumin, commonly known as Jeera and scientifically known as *Cuminum cyminum* an annual and one of the most important spice crop that is more prone to several diseases among which the aerial diseases cause ruthless damage to its yield and quality. Aerial diseases are those diseases which cause de-formalities in above ground system of the plant and may include stem, leaves, flower, seed, fruit etc. They may also disturb the translocation of water, food and minerals. The threats of Aerial disease are epidemics in crop production, high cost of chemical fungicides and development of fungicide resistance, climate change, new disease outbreaks and increasing concerns regarding environmental as well as soil health are becoming high. These demand the use of integrated approaches to address aerial disease management strategies for the crop. This article summarized the methods for management of aerial diseases in crop production which included legal methods, resistant cultivars, sanitation cropping system, biological control, soil amendments, soil fertility, weather parameters, plant nutrients, and chemical control. Decision support systems developed to predict disease allow choosing good management methods such as the use of healthy seeds, cultural practices and biological control agents for each aerial cumin disease. The complexity in interactions between a pathogen and its host, influenced by biotic and abiotic factors of the environment, build the control of the diseases frequently very hard. However, profound awareness of host-pathogen systems allows constructing integrated pest management systems enhances the production of good quantity as well as quality seed.

Introduction

Cumin (*Cuminum cyminum L.*) with chromosome (2n=14) is an annual herb belongs to Apiaceae family which is grows to a height of 15- 30 cm according to environmental conditions. According to Panday *et. al.,* (2019) cumin is native of Iran and Syria (Medeterian region). Cumin is known as one of the most important medicinal plants in Iran (Meena *et al*., 2018a; Moraghebi and Aghelpasand, 2008). Cumin seeds have an aromatic fragrance due to cuminol. Cumin is produced in India, Iran, Lebanon, Cypress, Egypt, Syria, China, Indonesia, Mexico and Iran (Meena *et al.,* 2018a). India is the largest producer (70% of world production), exporter and consumer of cumin seed across the globe (Shastry and Anandaraj, 2014). In India cumin was produced 9.12 lac tonnes from 12.76 lac hectare areas during 2019-20 (Anonymous, 2021). Cumin is very much vulnerable to a range of pathogenic organisms that reduce yield by killing the plant or damaging the product, thus making it unmarketable. Aerial diseases are considered a major limitation to crop production. Aerial major plant pathogens which appears at farmer fields are *Alternaria burnsii* causes blight, *Erysiphe polygoni* causes powdery mildew, *Alternaria alternata* causes leaf spot disease, *Pseudomonas cumini* causes bacterial blight disease and phytoplasma causes witches broom disease (Khare *et al.,* 2014) while *VDMV* (*Vanilla distortion mosaic virus*) causes yellowing disease is a new disease and reported recently in cumin (Meena *et. al.* 2022). Aerial diseases in cumin may causes up to 100% crop damage on susceptible cultivars under ideal conditions and hence these diseases are among the major factors contributing to low yields of organic produce. The respective pathogen often survive for long periods in host plant debris and so they remained in field, soil organic matter or nearby on alternative hosts. Accurate diagnosis of a specific disease is difficult due to the similarity in symptoms such as seedling stunting, bark cracking, yellowing and branch dieback which in turn makes the disease harder to manage. With the rising awareness of the adverse effects of chemical pesticides, people are looking for organically grown vegetables and managing aerial pathogens by natural means. Consumers are increasingly choosing organic foods due to the perception that they are healthier than those conventionally grown.

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Important aerial diseases of cumin

Fungal blight:

Fungal blight or usually called Alternaria blight disease in cumin was reported first from Gujarat by Uppal *et al.* (1938). It is caused by a fungal pathogen that scientifically known as *Alternaria burnsii* (a member of imperfect fungi group). It is a very common and one of the most important diseases of cumin that causes heavy loss. Now, it is a common disease in all the cumin growing areas favoured by humid and cloudy weather (Khare *et al.,* 2014). Initially small necrotic spots develop on almost all the aerial parts which enlarge, coalesce and turn brown to black. Under humid conditions stem and flowers are also infected which may be killed. Either seeds are not formed on diseased plants, if produced they remain small, shriveled, very light and blackish. 23-28°C temperature range is optimum for the disease development (Ghemawat and Prasad, 1972). Early planting results in greater severity of the disease and the pathogen is seed borne and seed transmitted (Khare *et al.,* 2014). It is also soil borne surviving in crop debris. Sekhawat *et al.* (2013) have reported five pathogenic groups of which the isolate from Jalore district was most virulent. Volatile oil content of seeds is reduced due to the disease. According to Lakra (2005) the incidence of Alternaria blight increased with the increase in the duration of dewfall, leaf wetness, relative humidity, congenial temperature and number of rainy days. Arora *et al.* (2008) planted 25 cumin cultivars at 5 days interval from 15th October to 15th December and observed that period of ten weeks from sowing was favourable for initiation and spread of the blight. December sown crop had least disease incidence while highest blight incidence was in October sown crop (Champawat and Singh, 2008).

Management

Seed treatment with difolatan, captan is beneficial, mancozeb, copper oxychloride, zineb are recommended as spray (Gemawat and Prasad, 1969). Sharma *et al.* (2013) recently evaluated ten fungicides of which propiconazole (0.1%), carbndazim + iprodione (0.2%) chlerothalonil (0.2%) were better in giving least disease incidence and higher yield (Khare *et al.,* 2014). Akbhari and Dhruj (1995) tested nine fungicides and found three sprays of Mancozeb (0.2%) best in checking the disease resulting in higher yields. It was followed by propiconazole. Cumin plants are generally attacked by *A. burnsii* after flowering. This is a low sugar disease. It has been observed that maltose and sucrose are not present in plants before flowering. They are present at flowering and disappear in mature plants and seeds. D-mannose and benzedene have been found in plants before flowering but not at flowering and in diseased plants. Presence of maltose and sucrose after flowering and in the diseased plants exhibit their support to the pathogen and to make the plant susceptible (Khare *et al.,* 2014). The presence of Dt serine and phenylamine creat favourable conditions for the disease development (Gemawat and Prasad, 1969). *Trichoderma harzianum* when applied in the soil grown on sorghum seeds (24 g/6 m^2) resulted least blight disease. Similarly when 10% spore suspension of *T. harzianum* was used as seed treatment and as spray at flowering resulted in best control of the disease (Deepak *et al*, 2008). Meena *et al.* (2010) in advanced production technology of cumin have recommended seed treatment with thiram or carbendazim to control seed borne pathogens and mixing of 100 g *Trichoderma* formulations with one kg seed to control most of the diseases of cumin. Prophylactic spray of 0.2% Mancozeb or Difolatan or Zineb is suggested during cloudy weather or at first symptoms (Khare *et al.,* 2014). The plant protection schedule comprising seed treatment with carbendazim + thiram (1:1) or tebuconazole, soil drenching with metalaxyl or carbendazim and foliar application of mancozeb followed by propiconazole and dinocap at later stage proves effective to combat wilt, blight and powdery mildew of cumin (Sharma *et al.* 2011). Further, prophylactic spray of chlorothalonil followed by two sprays of azoxystrobin or propiconazole efficiently manages the cumin blight disease under field conditions.

Powdery mildew:

Powdery mildew of cumin is caused by a fungal pathogen (*Erysiphe polygoni* DC). The fungus is ectoparasite on aerial plant parts resulting in yield losses upto 50% under favourable weather conditions (Khare *et al.,* 2014). The disease appears in February and March at the flowering time. The disease spreads fast under warm (27-35°C) and moist conditions. The seeds formed on the diseased plants remain small shriveled and lighter in weight. All the plant parts get covered with white powdery mass of conidia. The late sown crop under irrigated condition gets severely affected (Khare *et al.,* 2014). The fungus perpetuates as dormant mycelium on the seed. The perfect stage is not formed in India. Under severe disease situation total failure of the crop has been observed (Champawat and Singh, 2008). The disease is common in Bulgaria where perithecial stage has been reported (Dodoff and Naceff, 1936).

Management

Single dusting of 300 meshes sulphur 20-25 kg ha^{-1} at the time of flowering in January is essential (Khare *et al.,* 2014). Dinocap (0.1%), carbendazim (0.1%), tridemorph (0.05%) and wettable sulphur (0.2%) are also effective (Sharma *et al.,* 2013; Mathur *et al.*, 1971; Gohil *et al.*, 1985, Meena *et al.*, 2010). At the initiation of the disease dusting of sulphur powder @25kgha^{-1} completely manages the powdery mildew disease.

Cumin yellowing:

Cumin yellowing is comparatively a new viral disease in cumin and may be characterized by a group of symptoms like mosaic, leaf distortion, enation, yellowing of leaves, stunting and bushy type growth (Balaji *et al.,* 2014), was observed on young plant leaves initially and then extended to whole aerial plant parts. Average losses from the disease were reported up to 30% yield. In a survey cumin plant samples, exhibited chlorosis and mosaics. Electron microscopy showed presence of flexuous, rod shaped and filamentous nucleocapsid, approximately 680 nm long and 12 nm in diameter, with similarity to particles from the genus *Potyvirus* (Meena *et al.,* 2022).

Other microorganisms:

Ten fungal species associated with cumin seeds- *Alternaria alternata, Aspergillus flavus, A. niger, A.ochraceus, Bipolaris hawaiiensis, B.spicifer, Curvularia prasadii, Chaetomium sp. Fusarium moniliforme* and *Rhizopus oryzae* were reported by (Jain and Jain, 1995). These are not usual pathogens causing diseases of importance in cumin but they influence the germinability of seed and may infect aerial plant parts.

Legal Methods of plant disease management

Most of the developing countries, either due to lack of technology or skilled manpower or both, suffer more from the diseases that are being imported with the seeds and plant materials. The regulatory measures are constantly being updated and enforced. However, even with quarantines, there is always a risk of additional aerial plant pathogen introductions. (Panth *et al.*, 2020). Legal methods are any regulation, rule, law or quarantine that prevents the movement of a disease-causing agent or a pest from a country, region, and state. The long-distance movement of aerial plant pathogens may occur through packing materials, containers, seeds, plant material, plant products, animals, soil or even humans. Introduced new pathogens can stay below the detection threshold level for several years and can emerge later with destructive intensity (Crooks, 2005). Several studies shown that the plant trade is one of the main pathways for the dispersal of pathogens such as *Phytophthora* species (*P. ramorum, P. drechsleri, P. hedraiandra, P. hibernalis, P. nicotianae, P. palmivora and P. syringae*) in plants (Goss *et al.*, 2009; Moralejo *et al.,* 2009).

Sanitation of field and surroundings

By means of the resting structures like chlamydospores, oospores, microsclerotia or sclerotia and basic reproductive systems, aerial plant pathogens can stay alive in the soil for a very elongated time, yet in the absence of a living host or plant debris and soil organic matter. Therefore, it becomes very important to remove the plant debris away from crop growing areas whenever possible residue breakdown. Sanitation includes any kind of activities aimed to prevent the spread of pathogens by removing diseased and infected plant parts, sanitization of tools and equipment and washing hands and feet (Panth *et al.*, 2020). Weeds surrounding or even in field and volunteer plants should be ruined as they can function as a host for several aerial pathogens as well as increase the relative humidity (change in microclimate) around the crop canopy, creating an environment in which many pathogens flourish for longer period. Ploughing infected crop debris is also a good sanitation measure to control certain aerial plant pathogens because the tillage can expose the infected plant materials to the direct sunlight, that can kill some plant pathogens. The diseased plants and the nearby soil around its canopy should be discarded to decrease the further extend of some diseases (Baysal-Gurel *et al.*, 2018). Meena *et al.,* 2018b found that cumin seed takes 10-12 days in germination which is more than enough to cover the cumin field by the weeds as weed seed usually takes few days only. Cumin, being a short size crop with slow initial growth, heavily infested with several weed species which cause severe competition, resulting in yield reduction of cumin up to 99%. Solarization significantly reduced weed pressure in cumin crop and increases yield.

Disinfection of tools and equipments

Tools that are used should be washed disinfected or cleaned at a minimum, when moving equipment between different plants or fields using different methods such as heat treatment, ultraviolet (UV) treatment and chlorine treatment. Thus, preventative measures should be adopted to avoid pathogen contamination. Field sanitation in combination with many other methods can yield a desirable outcome. This is the first step for the management of aerial diseases in an integrated system (Panth *et al.*, 2020). .

Summary

Control of the aerial diseases worldwide is becoming a great challenge along with sustaining the quality of degraded soils as an increasing crop production in them. Using antagonistic microorganisms and phytochemicals in controlling aerial infecting fungi offers an alternate approach to the prevalent use of synthetic pesticides. Mixtures of several bio-control agents that have the benefit of exercising a broad spectrum activity against several pathogens. This review established that a single management approach or practice such as a biological amendment or crop rotation, alone will probably not be effective in establishing aerial disease suppression, but multiple approaches such as combinations of crop rotations, cover crops, organic and biological amendments, soil solarization, and chemical measeures as well as legal management need to be optimized and coordinated together as part of an integrated pest management program. Active management of soil microbial communities for disease suppression through the use of effective crop rotations and biological amendments has a huge potential

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