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Anthracnose of chilli

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Abstract
Anthracnose disease, is reported as a major constraint in the production of chilies in tropical and subtropical countries, resulting in significant losses. The anthracnose disease has caused a 10–54 per cent reduction in crop yield in India. Chilli anthracnose management has been a burning issue for agriculturists and farmers because no effective control measures have been proposed to date. The decline in chilli production and the deterioration of fruit quality have heightened the need for a long-term strategy to combat the disease's spread. There is no single management technique that can effectively control the disease. The use of a combination of different strategies to manage the disease is generally recommended.

Keywords: Anthracnose, disease, management

1. Introduction

The spicy delights of Indian cuisine are well-known and celebrated around the world. Whole or powdered chilli is indeed an inevitable presence among the spices used to stimulate the taste receptors in Indian cuisine. Chilli, in addition to being an important component of Indian cuisine, is also an important economic commodity, accounting for a significant portion of the Indian economy. Chilli has numerous health benefits for humans. Fresh green chilli fruits have more Vitamin C than citrus fruits, while red chilli fruits have more Vitamin A than carrots. Capsaicin, the spice's active ingredient, has antioxidant, anti-mutagenic, anti-carcinogenic, and immunomodulatory properties, inhibiting bacterial growth and platelet activation. Chilli (*Capsicum annum* L.) is a key ingredient in the cuisines of tropical and subtropical countries, as well as the world's fourth most cultivated crop. Chillies are grown in over 400 different varieties around the world. These are nutritionally rich in Vitamin A and C, as well as iron, potassium, and magnesium, all of which help to boost the immune system and lower cholesterol (Grubben and Mohamed El, 2004) [4]. *Capsicum* is a Solanaceae family member with approximately 22 species and five tamed species. *Capsicum* species, which have chromosome number 2n = 24, can be a herb or sub-shrub that grows up to 2.5 metres tall and has a hairy stem with red or purple spots near the nodes.

Fig 1: Anthracnose of chili

Anthracnose disease is reported as a major constraint in the production of chillies in tropical and subtropical countries, resulting in significant losses. The anthracnose disease has caused a 10–54 per cent reduction in crop yield in India (Lakshmesha *et al*, 2005) [7]. Significant losses have also been reported from many other parts of the world, such as a substantial amount of 20–80 per cent loss in Vietnam (Don *et al*, 2007) [8].

The pathogen's involvement after and before harvest causes a loss of 10–80 per cent of the Marketable yield of chilli fruits, resulting in a high loss (Than *et al*., 2008). The fruit abscess is the most economically essential part of the disease because even a small lesion on the fruit can be devastating. *Colletotrichum* spp. Is one of the world's ten most controversial pathogens, responsible for widespread crop losses (Dean *et al*, 2012) [9]. *Colletotrichum* is an asexual species of Fungi imperfectii that belongs to the phylum Ascomycetes and the Coelomycetes class (Dean *et al*., 2012) [9]. With its ability to infect many hosts along with adapting to new environments, the pathogen poses a serious threat to the different crop production systems through cross-infection problems. Anthracnose can affect leaves, stems, and fruits before and after harvest. Circular or angular hollowed lesions with concentric circles of acervuli which are often wet and generate pink to orange conidial masses are typical fruit symptoms. This review aims at providing an overall context regarding Anthracnose Disease Resistance in Chili and its progress.

2. Anthracnose causing pathogen

Anthracnose is the common name for plant diseases characterised by extremely dark, sunken lesions containing spores. It is derived from a Greek word meaning 'coal'. *Colletotrichum* species, which belong to the kingdom Fungi, Phylum Ascomycota, category Sordariomycetes, Order Phyllachorales, and Family Phyllachoraceae, cause anthracnose disease. *Glomerella* species are the anamorphs. Anthracnose attacks chilly fruits both before and after harvest, causing anthracnose lesions. Chilli fruits with even minor anthracnose lesions lose their marketability. Different *Colletotrichum* species are linked to anthracnose of the same host in the *Colletotrichum* pathosystem (Simmonds, 1965; Cannon *et al*., 2000) [10, 5]. Different *Colletotrichum* organisms can also play a role in a variety of diseases that affect mature chilly fruit. *C. Capsici* is found in abundance in red chilli fruits, whereas *C. acutatum* and *C. gloeosporioides* are abundant in both young and mature inept fruits (Hong and Hwang, 1998) [11].

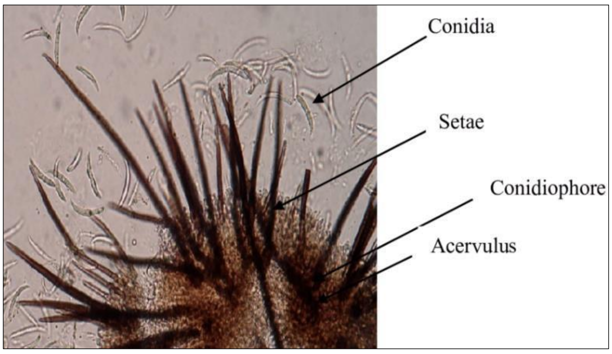

Fig 2: Conidia, setae, conidiophore, acervulus of *C. Capsici*

Colletotrichum species live as acervuli and micro-sclerotia in and on seeds. Mycelia and stomata were found to survive in colonised chilli seeds. The seed coat endosperm and embryo of strongly colonised seeds had abundant intercellular and intracellular mycelia and acervuli, indicating disintegration of parenchymatous layers of the pericarp and depletion of food material in endosperm and embryo (Chitkara *et al*., 1990) [15]. Alternative hosts for fungi include other solanaceous or legume crops, plant debris, and rotten fruits in the field. *Colletotrichum* species produce micro-sclerotia to allow dormancy in the soil during the winter or when stressed, and these micro-sclerotia can live for many years. Conidia from acervuli and micro-sclerotia are splashed by rain or irrigation water from diseased to healthy fruit and foliage during warm and wet periods. Attachment of conidia to plant surfaces, germination of conidia, production of adhesive appressoria, penetration of plant epidermis, growth and colonisation of plant tissue, and production of acervuli and sporulation are all part of the initial infection by *Colletotrichum* species (Bailey and Jeger, 1992) [16]. Anthracnose is primarily a problem on mature fruits, causing pre- and post-harvest fruit decay, as well as significant economic losses (Bosland and Votava, 2003) [6]. Appressoria that have developed on immature fruits could well remain dormant until they mature or ripen.

3. Anthracnose epidemiology

Any disease's severity and spread are largely determined by environmental factors. The disease spreads due to favourable host, pathogen, and weather conditions (Agrios, 2005) [1]. Chilli anthracnose is much more common in tropical and subtropical countries. The disease is spread more easily in hot and humid environments. Different levels of disease severity may be caused by relationships between rainfall intensity, timeframe, crop geometry, and inoculation dispersal. Temperature interactions with other factors like leaf surface wetness, humidity, light, and competitive microbiota are common. The link between environmental factors such as rainfall severity and duration, as well as current temperature and humidity, crop geometry, and inoculum spread, can lead to pathogenicity (Dodd *et al*., 1992) [17]. Infection is most common in warm, wet weather. Temperatures of around 27°C and high humidity (an average of 80%) are ideal for disease development (Roberts *et al*., 2001) [18]. *Colletotrichum* species invade host tissues using a variety of strategies, ranging from intracellular hemibiotrophic to subcuticular intramural necrotrophy (Bailey and Jeger, 1992) [16]. The progression of the disease is also influenced by the host cultivar's rigidity to the pathogen.

There are only a few detailed studies on *Colletotrichum* species' infiltration and colonisation of chilli. During the infection process of *C. Gloeosporioides* in susceptible chillies, Kim *et al*, (2004) [12] realised that no biotrophic infection vesicle was discovered (*C. Annuum cv. Jejujaerae*). Cell damage extended towards the plant's subepidermal cells, which are likely to be destroyed by pathogen enzymes, as epidermal cytoplasm became condensed and small vacuoles increased. The pathogen colonised tissues intercellularly and intracellularly at later stages of infection. This structural characteristic indicated that necrotrophic fungal growth was in charge of the infection.

Colletotrichum species can generally survive on or in the seeds, and infected transplants are among the ways anthracnose is introduced to the chilli field. *C. Capsici* infection of chilli has been shown to have two routes of entry: through the seed coat and through the testa openings. root rot induced by *C. Capsici* in seedlings, however, whether chilli anthracnose can be transmitted through seeds, and the role of seed infection and seedling infection in pre and poste mergence damage to chilli plants are still unknown. It was discovered that *C. Acutatum* can infect chilli seeds by reducing germination percentage or causing sapling damping off.

4. Chilli Anthracnose Disease Management

Chilli anthracnose management has been a burning issue for agriculturists and farmers because no effective control measures have been proposed to date. The decline in chilli production and the deterioration of fruit quality have heightened the need for a long-term strategy to combat the disease's spread. There is no single disease management technique to effectively control the disease. The use of a combination of different strategies to manage the disease is generally recommended (Agrios, 2005) [1]. The use of cultural practices, chemical control, resistant varieties, and eventually, biological control can be discussed as management strategies for preventing *Colletotrichum* spp. From expanding and establishing a disease.

4.1 Using cultural practice

Since the pathogen is a soil-borne in addition to seed, wind, and water-borne, practices controlling its spread should focus on 3 important areas of disease-free crop production in the field: proper drainage, crop rotation, and the removal of any infected plant parts. Water splashes have the potential to easily spread pathogen conidia from infected to uninfected plant parts. In addition, relative humidity promotes pathogen colonisation. The field should have proper drainage and irrigation to prevent the disease from spreading. Additionally, proper spacing between plants should be maintained to reduce dense canopy, which allows moisture to be created (Than *et al*., 2008). Crops that aren't *Colletotrichum* hosts should be rotated every two to three years. Weeds as well as solanaceous volunteers should be controlled around transplant

Houses to keep them clean. The field should drain well and be free of diseased plant debris. Crops should be rotated away from solanaceous plants for at least two years if the disease was previously present (Roberts *et al*, 2001) [18].

Choosing cultivars with a shorter ripening period may help the fruit avoid becoming infected with the fungus. Wounds in fruit caused by insects or other means should be minimized as much as possible because wounds provide entryways for *Colletotrichum* spp. As well as other pathogens that cause soft rot, such as bacteria.

4.2 Usage of chemicals

Traditionally, recommended fungicide for the control of the disease is manganese ethylenebisdithiocarbamate (Maneb, Smith, 2000) and carbendazim, though the use of both fungicides has been found ineffective under severe disease outbreak. The chemical fungicides generally recommended for controlling anthracnose disease are based on copper compounds, dithiocarbamates, benzimidazole and triazole compounds. However, fungicide tolerance can develop quickly if a single compound is used excessively. The strobilurin fungicides azoxystrobin (Quadris), trifloxystrobin (Flint), and pyraclostrobin (Cabrio) have recently been labelled for the control of chilli anthracnose, but preliminary reports on their efficacy against the severe form of the disease are only available (Alexander and Waldenmaier, 2002; Lewis and Miller, 2003) [19, 20]. Under normal weather conditions, the disease can be managed with a reasonable spray programme. Rotation of two or more distinct classes of fungicides is strongly recommended for improving the likelihood of better disease protection in the fields (Förster *et al*, 2007) [21].

4.3 Using cultivators with resistance

The most important and long-term strategy for managing the disease is to develop immunity against the pathogen within the host. This strategy not only eradicates disease-related losses but also eliminates the chemical and mechanical costs of disease control (Agrios, 2005) [1]. The goal of using resistant cultivars is to activate the host defence response, which then inhibits or slows the pathogen's growth. This is accomplished by combining two genes: a host resistance gene and a pathogen avirulence gene (Flor, 1971) [22]. Due to the association of more than one pathogen species with the disease (Sharma *et al*., 2005) [23], as well as the differential ability of the pathogenic virulence, the difficult task of resistant breeding in the *Colletotrichum*-chilli pathosystem is exceptionally difficult. Information on *Colletotrichum* resistance varieties can also be used to investigate how resistance is passed down from generation to generation (Kim *et al*., 2008) [13], as well as to locate and study resistance QTL maps (Kim *et al*, 2008) [13].

4.4 Usage of biological controls

In recent years, disease control using botanicals and crude extracts of medicinal plants has been investigated for their antifungal and antimicrobial properties. Their ease of decomposition, lack of residual activity, and lack of phytotoxicity make them popular for controlling phytopathogens. Lenné and Parbery proposed the possibility of biological control of *Colletotrichum* species as early as 1976. (Jeger and Jeffries 1988) [24] also emphasised the potential of *Pseudomonas fluorescens* for biological control of post-harvest fruit diseases. *C. capsici*, Thailand's most common anthracnose pathogen, was found to be effectively controlled by antagonistic bacterial strains (dgg13 and BB133) (Intanoo and Chamswarng, 2007) [25]. *Trichoderma* species are also thought to be able to compete effectively for surface area, reducing pathogen infection success (Maymon *et al*, 2004) [26].

5. Current status and future aspects of Anthracnose disease management

Anthracnose disease management and control are still being studied extensively (Yoon *et al*, 2004) [12]. The use of resistant cultivars is the cheapest, easiest, safest, and most effective method of disease control.

This will not only eliminate disease-related losses but also lower the cost of chemical and mechanical control, as well as reduce environmental contamination from toxic chemicals. *Capsicum annuum* cultivars resistant to the pathogens that cause anthracnose have yet to be developed.

Nonetheless, some *Capsicum* species, such as *C. baccatum* have shown high levels of resistance to the *Colletotrichum* species that infect chillies. Despite the fact that there is currently extensive research on disease control management, including breeding programmes for anthracnose resistant cultivars, the current state of the chilli anthracnose disease requires improvement. An understanding of the pathogen's culture would provide crucial information for developing targets for developing pathogen-resistant chilli varieties. Modifications to traditionally recommended cultural practises that are appropriate for a specific agro-climatic region will also aid in disease management. More research is needed to learn more about the pathogen's various modes of infection and the pathogenic variance associated with post-harvest and pre-harvest losses in crop production in different regions.

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