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Chilli anthracnose: A review of causal organism and their managements

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Abstract
Indian cuisine is renowned and celebrated throughout the world for its spicy treat to the tongue. The flavor and aroma of the food due to the use of spices creates an indelible experience. Among the commonly utilized spices to stimulate the taste buds in Indian food, chilli constitutes an inevitable position. Chilli is the major spice crop, accounting for about 30 per cent of total spice production in the country. Besides being a vital ingredient of of Indian food, chilli contributes major share in Indian economy. Chilli also has uncountable benefits to human health. Fresh green chilli fruits contain more Vitamin C, while red chilli fruits have more Vitamin A content. India has been one of the major producers and exporters of chilli. The decline in chilli production has been attributed to the diseases associated with chilli crop. Anthracnose disease is one of the major economic constraints to chilli production regions and it is gaining much attention towards causes of damage. The disease causes damage to both mature fruits in the field as well as during their storage under favorable conditions. This review gives an account of the identification of *Colletotrichum capsici.* Also, the review highlights the various management strategies for the causal agent of the disease, associated with the chilli anthracnose.

Keywords: Chilli anthracnose, causal organism, their managements

Introduction

Isolation and purification of *Colletotrichum capsici*

Pathogen *Colletotrichum capsici* isolated from anthracnose lesions of affected fruits of chilli (Rajapakse and Ranasinghe, 2002; Roat *et al*., 2009; Singh *et al.,* 2009; Linu and Jisa, 2013; Raj *et al*., 2014) [29, 32, 38, 19]. *Colletotrichum capsici* also isolated from diseased plant parts of chilli showing anthracnose symptoms, particularly die-back and ripe fruit rot (Akhtar and Singh, 2007; Ratanacherdchai *et al*., 2010) [2, 31] and seed mycoflora associated with seeds collected from fruit rot infected chillies (Mesta *et al*., 2007; Subhani, 2015; Vinaya *et al*., 2009) [22, 41, 45]. Pathogen (*Colletotrichum capsici*) isolated by tissue isolation method (Naik *et al*., 2008; Linu and Jisa, 2013; Raj *et al*., 2014) [25, 19, 27] and monoconidial culture was obtained through single spore isolation technique (Sharma *et al*., 2005; Subhani, 2015) [34, 41].

Morphological studies (micrometry)

Colletotrichum capsici was identified on the basis of morphological characters, pathogenicity (Masoodi *et al*., 2012) [21] sporulating acervuli, conidia, setae and disease symptoms on chilli fruits (Subhani, 2015) [41]. *C. capsici* isolates produced a large number of black acervuli on culture media at early stages (3 days) which later became light brown or brown after 14 days (Rajapakse and Ranasinghe, 2002) [29]. Acervuli were round, elongated, approximately 350 µm in diameter. Setae were abundant, brown, 1-5 septate, rigid and hardy, swollen at the base, slightly tapered towards the polar acute apex, having 250 µm length and 5-8 µm wide. Conidia were falcate, fusiform with acute apices and narrow truncated, one-celled, hyaline and uninucleate (Akhtar *et al*., 2008) [1]. *Colletotrichum* spp. produced cottony colonies on PDA with a colour of grayish-white to dark grey on the ventral surface whereas, the reverse of the colonies was mainly black (Sangdee *et al*., 2011) [33] and at first the colonies were white later the older mycelium rapidly became brown (Rajapakse and Ranasinghe, 2002) [29]. Most of the isolates produced cottony, fluffy or suppressed (Sharma *et al*., 2005; Christopher *et al*., 2013) [7, 34] and dark black-grayish yellow colonies with saffron colour conidial mass (Damayanti *et al*., 2009). The colony diameter of different groups ranged between 74 and 85 mm after 10 days incubation (Sharma *et al*., 2005) [34].

Nutritional study on different culture media

The maximum radial mycelial growth of *C. capsici* was recorded in Richard's, Brown's and PDA (Rani and Murthy, 2004) [30], followed by Czapek's agar Asthana and Hawkar's medium (Ekbote *et al*., 1997; Venkataravanappa and Nargund, 2007) [9, 44]. Malt extract, host leaf extract agar and synthetic media, rose bengal and Richards's agar were also supported good radial mycelial growth of the fungus (Mamatha *et al*., 2006) [20]. Mycelial growth of the isolates on different culture media differed from each other (Akhtar and Singh, 2007) [2].

Management of chilli anthracnose

Use of fungicides

Fungicides *viz*., Hexaconazole (0.1%), Propiconazole (0.1%) and Triademefon (0.1%) were effective against the fruit rot pathogen (*C. capsici*) of chilli to inhibit mycelial growth (Hegde *et al*., 2002) [13]. Propiconazole exhibited the highest level of inhibition *in vitro* in mycelia growth, sporulation and spore germination at concentrations as low as 0.1 µg/ml (Gopinath *et al*., 2006) [10]. Carbendazim and Thiophanate-methyl @ 0.1% each could highly effective against *Colletotrichum capsici* (Ushakiran *et al*., 2006; Banginwar *et al*., 2012) [43]. Carbendazim and Triademefon inhibited the growth of fungus to a maximum extent (Singh *et al*. 2010) [39] followed by Propiconazole, Penconazole and Thiophanate-methyl (Naik *et al*., 2008) [25]. *C. capsici* were highly sensitive to Chlorothalonil followed by Propiconazole, Aliette and Mancozeb in chilli crop (Shwati and Raut, 2011. Goud and Mansa, 2013) [36, 11]. Benomyl (0.25%) cause no sporulation of *Colletotrichum capsici* (Barhate *et al*., 2012) [5]. The highest inhibition of enzyme production was observed in Propiconazole, Difenoconazole and Carbendazim (Gopinath *et al*., 2006) [10].

Use of botanicals

Onion bulbs extract *(Allium cepa* L.) (Hegde *et al*., 2001), *Azadirachta indica* leaf extract, *Pongamia pinnata* leaf extract (Yadav *et al*., 2009) [46] and *Tagetes erecta* leaf extract gave complete inhibition of mycelial growth and spore germination of *Colletotrichum capsici* (Singh *et al*., 1997) [40]. Neem seed kernel extract (NSKE) are highly effective followed by neem leaf extract (Naik *et al*., 2008; Ngullie *et al*., 2010; Mishra *et al*., 2011) [25, 26, 23]. *Eucalyptus sp*., *Aegle marmelos*, *Nerium oleander*, *Lantana camara* (Banginwar *et al*., 2012) *Pimenta dioica* and *Maesa indica* (Yashoda *et al*., 2014) [47] are also found effective. Leaf extracts of *Polygala elata* and *Datura metel* exhibited the strong fungicidal activity against the *C. capsici* (Rajamanickam *et al*., 2012) [28].

Use of biological control agents

Biocontrol strategy for disease management has stood up as a sustainable approach required for homeostasis of the environment. Lenne and Parbery (1976) was elucidated the potential of using biocontrol agents (BCAs) for managing chilli anthracnose. The possibilities of using BCAs for controlling the post-harvest loss of fruits has been explained (Jeger and Jeffries, 1988; Korsten and Jeffries, 2000) [16, 17]. The BCAs include *Psuedomonas fluorescens, Trichoderma* spp., *Bacillus subtilis. Trichoderma* is a saprophytic fungus, it has high adaptive potential as evident from its ability to colonize wood, bark, agricultural wastes and other substrates (Singh *et al*., 2012; Mukherjee *et al*., 2014) [37, 24]. Mycoparasitim, antibiosis, competition (for nutrients and space) mechanism involved along with its ability to induce systemic resistance in the plants against the pathogens (Harman, 2006; Shoresh *et al*., 2010; Hermosa *et al*., 2012) [12, 35]. Also, the efficient enhancement in plant growth has been attributed to the application of *Trichoderma* species (Yedidia *et al*., 2001; Jain *et al*., 2012) [48, 15]. Fast colonizing ability and mycoparasitic nature has been involved in the *Colletotrichum* plant pathosystem (Begum *et al*., 2008) [6]. It has been further attributed due to the secretion of extracellular enzymes, that degrade the pathogenic mycelia and restrict growth and further colonization in the host tissue (Harman, 2006; Singh *et al*., 2012) [12, 37]. Effective results of antagonistic microbes like yeast, *Psuedomonas, Bacillus* etc. have been reported that control the growth and colonization of the pathogenic fungus (Anand *et al*., 2009; Sutarya *et al*., 2009) [3, 42].

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