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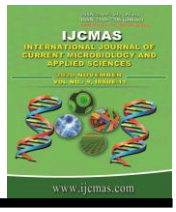

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Anthracnose of *Capsicum annuum* L. (Chilli)

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A B S T R A C T

Capsicum annuum (Chilli) is an important spice crop grown in tropical and subtropical areas. India is the global leader in production of chilli. Several biotic & abiotic constraints severely affect the yield of chilli. Among the biotic constraints the plant diseases play a vital role in the crop loss. Chilli is effected by several diseases, out of which anthracnose of chilli is one of the important disease. It is also termed as dieback or fruit rot. It is caused by *Colletotrichum capsici*. This devastating pathogen damages both immature and mature fruits reducing the nutritive and marketing value of chillies. This review article focuses on the nature of pathogen, symptomology and effective management techniques used for eliminating anthracnose of chilli.

Introduction

Capsicum annuum (Chilli) is an important spice crop grown in tropical and subtropical areas. It belongs to the family Solanaceae. India is the global leader in the production of chilli. The fruits of chilli are considered as vegetable and botanically called as berries (Saxena *et al.,* 2016).

Importance of chilli

India is the only one source for hot chillies. In India chillies are used as principle ingredient in various curries and chutneys. It is also used for vegetables, spices, condiments, sauces and pickle. It is widely used for its pungency and pleasant flavor. The capsaicin which is alkaloid present in the placenta and pericarp of the chilli fruits is the reason behind the pungency in chilli. In addition to the fact that it is utilized in numerous cooking styles it is found to have numerous therapeutic properties An experimental study shows that the capsaicin has anti-diabetic, anti-bacterial, analgesic and anti- carcinogenic properties (Geetha and Selvarani, 2017). Furthermore, chilli will decrease the cancer rate through

prohibiting carcinogens attachment with DNA and decrease the calorie intake through increasing thermogenesis. Fresh chillies are rich in proteins, minerals, vitamin A and C. Whereas dried chillies are rich in Vitamin A and D. Chillies are also having other antioxidants that are vitamin-A and flavonoids which includes *α-carotene, β-carotene, zeaxanthin, lutein* and *cryptoxanthin*. They are also good source of other antioxidants such as vitamin-A and flavonoids.

Constraints in chilli production

Being an important spice crop grown worldwide, there decreased production is due to biotic and abiotic constraints which significantly lead to the yield loss and seed production. Some of the biotic constraints are plant disease which play major role in crop losses. The plant disease is caused by fungi, bacteria, viruses or nematodes affect the chilli production in many parts of world (Saxena *et al.,* 2016). Chilli is usually affected by fungal diseases like anthracnose (dieback/fruit rot), Cercospora leaf spot, Damping off, Wilt, Leaf spots, Powdery mildew, Bacterial diseases like Bacterial Wilt, Soft rot and Some viral diseases like Cucumber Mosaic Virus (CMV), Tomato Spotted Wilt Virus (TSWV), Tobacco Mosaic Virus (TMV), etc. (Than *et al.,* 2008).

Historical ssignificance of anthracnose

Anthracnose was reported for the first time in Coimbatore of Madras Presidency – India (Sydow, 1913). The losses due to the impact of chilli anthracnose are estimated to be 50% in different parts of India (Pakdeevaraporn *et al.,* 2005). The average disease incidence level ranges between 66-84% and results in yield loss upto 12-50% (Thind and Jhooty, 1985). The disease was accounted to cause yield losses of 8-27% in Maharashtra, 20-60% in Punjab and Haryana and 30%-76% in Tamil Nadu (Bansal and Grover, 1969).

The pathogen

The pathogen responsible for anthracnose disease is induced by several *Colletotrichum* Species: which comes under the Family-Glomerellaceae; Order- Glomerellsles; Class-Sordariomycetes; Phylum-Ascomycota; Kingdom-Fungi (Agrios, 2005). The perfect stage was identified as *Glomerella.* Anthracnose disease has been induced by several species of *Colletotrichum* which includes *C. acutatum, C. coccodes, C. gleosporioides, C. atramentarium, C. dematium* and *C. capsici* (Gopinath *et al.,* 2006). There is an enormous variation among species of *Colletotrichum* causing anthracnose disease. Between the species already present, *C. capsici / C. truncatum* is a cosmopolitan fungus. In India *Colletotrichum capsici* is most prevalent in ripen chilli where *Colletotrichum acutatum* and *Colletotrichum gloeosporioides* induce disease in green and red chilli (Than *et al.,* 2008).

Disease incidence and transmission

Chilli anthracnose is seed and air borne disease and has a greater effect on seed germination and its vigour (Saxena *et al.,* 2016). The favorable temperature for the disease is 27°C with relative humidity 80% and a soil pH 5-6 (Roberts *et al.,* 2001). It damages the crop right from the early stage and continues till harvest. Hot and humid conditions are favorable for transmission of this disease.

Chilli anthracnose is a polycyclic pathogen, where the initial disease is induced by the spores of *Colletotrichum capsici* which survive in and on seed in the form of acervuli and microsclerotia (Montri *et al.,* 2009). The spores disseminate, deposit and germinate on

the surface of the chilli plants. From appressoria the germinating spore penetrate into the cuticle layer of plant and produce the infectious hyphae results in development of lesions (Yu *et al.,* 2013).

Symptomology of anthracnose disease in chilli

The disease symptoms appears on leaves, stem and also on the fruits. In nurseries, most common symptom is damping-off or seedling blight. At various stages of growth die back and leaf spotting occurs in plant. Die back symptom begins from the tip of the plants branches and finally reach downwards results in the progressive death of the branch. Rotting and fruit spotting occurs in ripe chilli with formation of acervuli in concentric rings, sunken necrotic tissues and coalesced lesion (Siddiqui *et al.,* 1977).

Symptoms on leaves

The symptoms appear on the leaves as small brown or black water soaked spots which are surrounded by light brown or yellow hallow margin. These spots were small at first, develop larger and get coalesced with each other to form a large lesion. These lead to necrotic spot and at later stages defoliation of leaves takes place from the crop (Fig. 1).

Symptoms on stem

Initial symptoms on the stem were brown spots leads to necrosis of twigs which finally ends up in die back of the plants at severe situation. Acervuli were found on the necrotic surface of the twigs (Fig. 2).

Symptoms on fruits

In fruits the initial symptoms were water soaked lesion on the surface of fruits which leads to necrotic tissue formation and further develops into elliptical spot. The lesion turned into concentric rings and the black pin head size acervuli are seen on the concentric lesion. Conidial mass also occurs on severe stage. The fruit become wrinkled, deformed, shriveled and dried when it is affected completely (Fig. 3).

Identification of the pathogen

Colletotrichum spp. can be identified from studies of Kulshrestha *et al.,* (1976) and Desai and Prasad (1955).

Colony character

When grows on plates its colony morphology can be observed with white to grey, a dark green center, and dense, filamentous mycelium (Than *et al.,* 2008). It takes 5-7 days for completing the mycelial growth in 9cm diameter Petri plate

Conidia

Consists of hooked shaped conidia produced from acervuli, a subepidermal fruiting body (Than *et al.,* 2008).

Fruiting body

The fungus produces black colored acervuli with disc shaped with dark needle like setae. The setae were dark brown to black color.

Disease management

No single management techniques have found to be effective against this disease. Integrated usage of physical, biological and chemical control has been recommended for effective management of this disease (Agrios, 2005).

Cultural practices: These are the precautionary measures. They are implemented to reduce the rate of infection

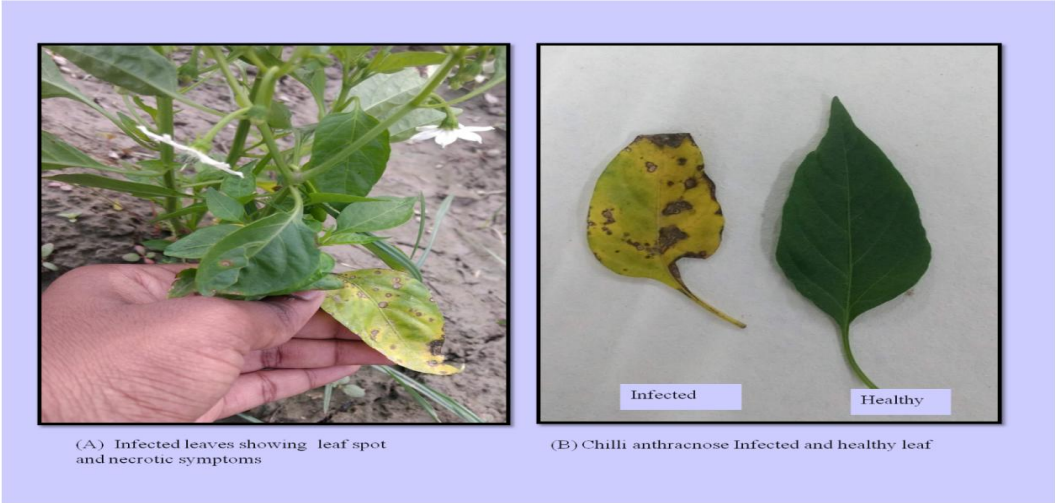
and minimize the inoculum pressure (Kiran *et al.,* 2020). As this pathogen is seed, air and water borne the cultural practices should focus on various cultural practices (Than *et al.,* 2008 and Ali *et al.,* 2016).

Crop rotation - rotation of chillies with other crops for which *Colletotrichum* is not an alternative host for a span of 2 – 3 years (Roberts *et al.,* 2001)

Proper drainage – There should be the proper drainage system to channelize the wate water out of the field because the conidia of the pathogen will easily spread from the infected plant to the non-infected plant through water splashes. Moreover relative humidity helps in successful colonization of the pathogen.

Weeding - Weeds should be eliminated from the area of sowing or transplanting.

Fig.1



(A) Infected leaves showing leaf spot and necrotic symptoms

(B) Chilli anthracnose Infected and healthy leaf

Fig.2

Fig.3

Usage of disease free seeds – Disease free seeds should be used to raise the chilli seedlings in the nursery or field.

Mulching – Utilisation of plastic mulches and rice straw has been reported to control this disease effectively (Vos *et al.,* 1995)

Deep ploughing – Deep ploughing at the end of the season can help in removing the infected crop debris from the field or cover the diseased plants deep into the soil (Sharma *et al.,* 2015)

Usage of resistant varieties – Two varieties (Tanjung-2 and Lembang1) from Indonesian Vegetables Research Center were proved to be moderately resistant (Setiawati *et al.,* 2008) and Five Varieties (AVPP0207, AVPP0513, AVPP0719, AVPP1004-B, AVPP1102-B) from World Vegetables Center, Taiwan reported to have tolerance to anthracnose (Hasyim *et al.,* 2014).

Biological control

Trichoderma spp. are widely applied for controlling *Colletotrichum* spp.in chilli (Boonratkwang *et al.,* 2007 and Singh *et al.,* 2007). They compete with the pathogen to occupy more surface area which in turn reduces the infection successfully (Kashyap et al.2017; Maymon *et al.,* 2004 and Jeffries *et al.,* 1992). *Pseudomonas fluorescens* can also be used to control the anthracnose. *Trichoderma* is well known saprophytic fungus which has a very wider adaptability. The biological control potential of *Trichoderma* is very well established against some devastating plant pathogens like *Colletotrichum, Alternaria, Pythium, Phytophthora, Rhizoctonia,* etc. (Singh *et al.,* 2012; Jain *et al.,* 2012; Imtiaj and Lee, 2008 and Begum *et al.,* 2008). The mechanisms that are involved are antibiosis, competition for nutrients and space and mycoparasitism (Hermosa *et al.,* 2012; Shoresh *et al.,* 2010 and Harman, 2006).

Chemical control

Out of various control methods, chemical control is regarded as the most effective (Akhtar, 2007). As the time required for giving the result is less, utilization of fungicides to control anthracnose has been more popularised (Wharton and Diéguez-Uribeondo, 2004). Relying on one single fungicide is not good, because continuous usage of a particular fungicide results in development of resistance (Staub, 1991). Maneb (Manganese ethylenebisdithio-carbamate) is traditionally the most recommended fungicide for the control of

anthracnose (Smith, 2000). Timely application of fungicides is very important. Other fungicides such as Mancozeb (0.2%), Ziram (0.1%), Copper oxy chloride and Bordeaux mixture (0.5 or 1%) were also found effective. Difenoconazole (0.025%) was significantly superior over rest of the fungicides (Propiconazole, copper oxychloride and Carbendazim + Mancozeb), which was recorded the minimum disease intensity of 21.13 per cent with highest fruit yield (Katedia *et al.*, 2019).

Dubey *et al.*, 2019 evaluated Five fungicides viz. Kasugamycin (Kasu B 3%SL), Pyraclostrobin + Metaram (Carbrio Top 60%WG), Azoxystrobin (Onestar 23%SC), Fusilazole (Cursor 40%EC) and Folicur 250 EC (Tebuconazole) for their efficacy against *Colletotrichum capsici* by Poison food technique. These fungicides were prepared at two concentrations viz. 250 ppm and 500ppm. Cabrio Top with per cent inhibition of 84.11% found to be best in inhibiting mycelia growth of pathogen and found to be superior over other chemical fungicides.

In conclusion, as chilli is an important spice crop. The devastating diseases such as Anthracnose should be counteracted effectively for increasing its marketability and consumption. This is only possible if one can easily detect, diagnose and manage the disease. As this disease is most prevailing and common the scientific community should develop integrated management approaches, as a step towards sustainability in agricultural production.

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