Introduction
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Plant pathogens adversely affect crop yield and create serious economic problems. Hence their control became an essential component of modern agriculture (Johal et al., 1995). The advent of modern agricultural practices comprises of the introduction of high yielding crop varieties, use of chemical fertilizers, assured irrigation facilities and improved agronomic practices. However, the intensive cropping system has also paved the way for the greater incidence of pests and diseases necessitating increased use of pesticides for plant protection. Thus, the evolution of agricultural practices resulted in greater chemicalization of agricultural Indiscriminate use of chemical pesticides has resulted into several risks and ill effects such as health hazards, ecological imbalances, resistance in the target population, emergence of newer pests and environmental pollution. In this regard, the uses of biopesticides and botanicals have assumed significance as an important component of IPM due to their economic viability and ecofriendly nature. They hold great promise as an alternative to synthetic pesticides to reduce pesticide load in the environment.

*Capsicum annuum* L. (Chilli), an annual sub-shrub constitutes one of the most important spices cultivated all over the world except in colder parts. India is the largest producer of chillies in the world. Chillies are grown practically all over India. India is well known as the land of spices the world over.

Chillies have an inseparable presence in the spice kaleidoscope. Being a well known commercial crop it is used as a condiment, culinary supplement or as a vegetable. Chillies are rich in vitamin *C* capsaicin, vanilin solanine and chilli oleoresin. *Capsicum* preparations are used as counter-irritants in lumbago neuralgia and rheumatic disorders (Pruthi, 1998).

Fifty one different pathogens have been reported to cause diseases on various parts of chilli (Saha and Singh, 1998). Out of them 39 belong to the fungi of class *Mastigomycotina*, *Ascomycotina* and *Deuteromycotina*, two are bacteria, six are viruses.
and four are nematodes. Among the major fungal diseases, anthracnose affects the yield directly by infecting fruits. Anthracnose (fruit rot) is a serious disease in chilli and in suitable weather, it may cause 12-35 percent of damage to the crop (Gomathi 2001).

In chilli plants, the disease anthracnose (literally means coal like) is caused by Colletotrichum capsici (syd) Butler and Bisby. It belongs to the order Melanconiales containing a single family Melanconaceae.

The ripe fruit rot of chilli caused by this fungus is a very serious disease. The ripe fruits, turning red, show elliptical lesions which are greenish black (or) dirty gray in color showing numerous dot-like black structures, the acervuli of the fungus. The fungus spreads to the central cavity of the fruit and infects the seeds. *C capsici* produces dense white to dark gray aerial mycelium, reverse of the colony is dark brown. Conidial masses are pale buff to salmon colored but individual conidia are hyaline, falcate fusiform, apices acute, 18-24 x 3.5 μ, setae numerous trichiform brown to blackish brown, 2-4 septate, 50 - 100 x 2.6μ. Appresoria are abundantly produced by the germinating conidia.

Disckson (1925) made a comprehensive review on the *Colletotrichum* spp.

Higgins (1926) described the morphology of *C capsici* Iing and I m (1944) described conidia of different spp of *Colletotrichum*. Durairaj (1956) reported that sucrose and ammonium sulfate were found to be suitable for the growth and sporulation of the fungus *C capsici*.

*C capsici* requires a temperature around 28°C, the relative humidity of 92% and optimum pH of 5.6 for its best growth (Chowdhury 1957). Mista and Mahmood (1961) reported the effect of vitamins and hormones on the growth of *C capsici*. Narmai and Das (1970) reported the colletotin toxin production by *C capsici*, which killed the host tissue. Rout and Rath (1972) established the seed borne nature of *C capsici*.
*Colletotrichum* spp. was reported to inhibit photosynthesis and physiology of the host plant (Grewal and Grower, 1974).

An important feature in the pathogenesis of fruit rot is the chemical mechanism of penetration of pathogens into the host and colonization of host tissue. It has been already reported that many *Colletotrichum* spp secrete pectinolytic and cellulolytic enzymes, which play a significant role in pathogenesis (Chacko et al., 1978, Manjeet Kaur and Deshpande, 1980; Cervone et al., 1981).

The effect of different culture media on the growth and sporulation of *C. capsici* and *C. curcumae* was studied by Palarpawar (1987). Muruganandam *et al.* (1987) reported the influence of some nitrogen sources and asparagine induced maximum appressorium formation. Cellophane favors the formation of appressorium than agar and glycine. An intriguing finding was the replacement of contact stimulus by glycine in the formation of appressorium by augmenting DNA synthesis, which is a prerequisite for appressorium formation in an anthracnose fungus.

Jindal *et al.* (1994) reported seed borne nature of *C. capsici* and its transmission in bell pepper. Datar (1995) conducted a survey to evaluate the damage of chilli fruits in the market. He reported that two species of *Fusarium, Drechslera australiensis* and *C. capsici* are responsible for post harvest damage. Among them *C. capsici* caused serious damage.

Manandhar *et al.* (1995) examined the conidial germination and appressorial formation of *C. capsici* and *C. gloeosporioides* on pepper fruits. The requirement of different nitrogen sources for the growth and sporulation of *Colletotrichum* spp was investigated by Palarpawar and Ghrude (1997).

Conidia of *Colletotrichum* spp. as soon as dispersed rapidly adhere to aerial parts of the plants, to initiate disease. The conidia are embedded in water-soluble mucilage, composed of high molecular mass glycoproteins, which is responsible for initial attachment of conidia to hydrophobic substrate (Hughes *et al.*, 1999). Following
germination, the spores produce short germ tube, which in turn develops appressorium, required for initial penetration of the plant cuticle and cell wall.

Praveen and Purohit (2001) reported the ultrastructure of conidium ontogeny in Colletotrichum capsici.

Chemical factors involved in the conidial germination of *C. capsici* on the surface of chilli pods were reported by Rajapakse (2002).

Fungicide development has been driven not by the occasional or regional fungal problems of crops but by their global value to the manufacturing industry. The discovery and development of effective chemical control emerged only in the mid-19th century. Currently, methods of agriculture and horticulture rely heavily upon the use of fungicides to the extent that some crops cannot be grown in their absence.

A good number of reports are available on the chemical control of *C. capsici*.

Chowdhury (1957) conducted spraying trials to control fruit infection of chillies by *C. capsici* and concluded that 3 to 4 sprays of poerenox, bordeaux mixture, dithane Z-78 and yellow cuproxide at 15 to 21 days intervals controlled the disease to a great extent and helped production of a higher percentage of healthy fruits.

Narain and Panigrahi (1971) evaluated the efficacy of antifungal activity of eight systemic compounds against *C. capsici*. They further reported that agrimycin 100 ( terramycin and streptomycin), aureofungin, thione, actidione at 10 ppm were found to have no inhibitory effect on conidial germination of *C. capsici*. Ziram was found to inhibit conidial germination of *C. capsici* and inhibit its infection on the fruits of *Capsicum annum*.

Raju *et al.* (1982) recommended capton as the effective fungicide for this disease due to its compatibility with pesticides like quinalphose, dimethoate, phosolone and carbaryl. Spraying with paushamycin at 200 ppm along with 0.3% blitox, 0.25%
and dithane M-45 controlled the incidence of *C. capsici* and Xanthomonas (Raju and Rao, 1984).

At present chemical fungicides dithane M 45, copper oxychloride, benomyl, capton, bavistin, ziram etc., are used to control *C. capsici* infection on chilli fruits. (Chakravarty *et al.*, 1981; Raju *et al.*, 1982; Hewitt, 1999).

It (Anonymous, 2002 a) was reported that the control of *C. capsici* infection of chilli was possible through the use of disease free seeds, hot water treatment at 52°C for 30 minutes and by crop rotation.

Sugunagar Reddy *et al.* (1980) reported that *C. capsici* isolates tolerant to copper sulphate are 4-5 fold more resistant to zineb. They concluded that even alternative use of different fungicides would be of no effect in controlling fungicides tolerant pathogen. Sariah (1989) reported benomyl resistance in *C. capsici* in the chilli growing field sites in Malaysia.

Evaluation of plant products against fungal pathogens in the recent past showed that they could be successfully used as effective alternative to currently used synthetic fungicides. Some of the research works on antifungal activity of plant extracts against fungal pathogens in general are given below.

The first authentic report on the antifungal activity of secondary metabolites was reported by Walker in 1925 (Sellaopathy, 2001).

Dixit *et al.* (1976) observed that flower extract of *Rosa indica* strongly inhibited spore germination as well as radial growth of *Curvularia pallescens*, *Cephalosporium sacchari* and *Fusarium nivale*.

Dhawale and Kolmelwar (1978) reported that seed leachates of chillies were found to inhibit *C. capsici*. 
Effect of flower extracts of five plants on conidial germination and mycelial growth was studied by Kapoor et al. (1981). They observed that *Evolvulus alsinoides* and *Convolvulus pluricaulis* almost completely inhibited growth of *Alternaria brassicae, A. brassicola* and *Fusarium oxysporum*.

Essential oil from *Hyptis suaveolens* was found to be fungitoxic with broad-spectrum activity (Pandey et al., 1982). Leaf extract of *Datura alba* and *Cannabis sativa* effectively reduced the seed mycoflora of *Eleusine coracana* and their population at 10% concentration (Pandey, 1982).

Maroon et al. (1984) reported that among the 43 plants screened, water extract of *Imaranthus spinosus* was the only effective extract both under laboratory and field conditions checking growth and *Cercospora* leaf spot development in mung bean.

Essential oil extract from the roots of *Curculigo orchioides* showed both antifungal and antibacterial activity (Jaiswal et al., 1984).

Antifungal assay of 10 medicinal plants against *Aspergillus* sp. and *Penicillium* sp. showed that only *Argemone mexicana* reduced growth of all the test fungi (Narn and Kadu, 1987).

Senthilnathan and Natasmohan (1987) reported the antifungal effect of protein part of aqueous extracts of *Aegle marmelos* and *Prosopis juliflora* against *Alternaria tenassima*.

Banana hands when dipped in 1% neem oil for three minutes recorded only 12% infection by *C. musae* even after 10 days whereas control fruits recorded 92.4% infection within 5 days (Ieyarajan, 1988).

Vapors of *Foeniculum vulgare* and *Pimpinella anisum* fruits showed complete inhibition on the spore germination of *C. capsici* (Shukla et al., 1989).
Tiwari et al. (1990) observed that only vapors of *Citrus medica* and *Cleome viscosa* completely inhibited radial growth of two storage fungi *A. flavus* and *P. oxalatum*.

Essential oil from *Ocimum canum*, *Pinus roxburghii* and fruit epicarp of *Citrus medica* reduced germination and viability of sclerotia of *Macrophomina phaseolina* (Dube, 1991).

Dhanapal et al. (1993) reported that aqueous extracts of neem leaf, unripe fruits, seeds and other commercial neem products effectively inhibited radial growth of *Rhizoctonia solani* and *Phytophthora meadi*. Singh et al. (1993) studied the efficacy of aqueous extracts of 11 medicinal plants to control banana fruit rot. Leaf extracts of *Azadnaghta indica*, *Ocimum sanctum* and *Ricinus communis* were found to be most effective in controlling the fruit rot.

Kalaachelvan and Sumathi (1994) reported that *Solanum nigrum* has solamargine, a steroid, which is inhibitory to the test fungi *Drechslera oryzae* and *Curvularia lunata*.

Ganesan and Krishnaraju (1995) observed that *D. oryzae* conidial germination was inhibited by 23 out of 36 plants tested. Bambwale et al. (1995) also reported that only one plant, *Lawsonia inermis*, out of 14 medicinal plants tested, inhibited conidial germination and mycelial growth of 2 important cotton pathogens *C. macrospora* and *Myrothecium oryzae*.

*Chromolaena odorata* leaf extract of 2% concentration inhibited growth, sporulation, sporangial germination, zoospore release and germination of *Phytophthora capsici* (Anandaraj and Leela, 1996).

Stivastava and Lal (1997) reported that out of ten plants tested, fresh leaf extracts of *Azadirachta indica*, *Calotropis procera*, *O. basilicum* stopped mycelial growth of *C. tuberculata* and *A. alternata*. Gehlot and Bohra (1997) reported antifungal
activity of certain halophytes against *A. solani*. The bark and leaf extracts of *Tamarix aphylla*, leaf and stem extracts of *Salsola baryosma*, stem and root extracts of *Atriplex lentiformis* and only stem extract of *Haloxylon recurvum* showed total inhibition of the potato blight pathogen.

The antifungal effect of grape proteins against fungal pathogens *Guignardia bedelli* and *Botrytis cinerea* was reported by Salzman *et al.* (1997).

Amodioha (1998) reported that leaf extracts of papaya have the potential to control powdery mildew disease of *C. annuum* in the field.

Garg and Jain (1998) reported that an essential oil from the rhizome of *Curcuma cassida* exhibited strong inhibitory effect towards all the bacteria and fungi used by them.

Five compounds isolated from *Eclipta alba* and *Wedelia trifolata* were tested for their antifungal activity against nine fungal species. The mixture of coumestans from *E. alba* showed maximum activity at 200, 100 and 50 ppm concentrations (Thyagarajan and Krishnamoorthy, 1999).

Vapour toxicity of 11 plants against *A. niger*, *Pestalotia palmarum* and *D. oryzae* mycelial growth was studied by Ganasan (2000). Praveen and Kumar (2000) evaluated aqueous extracts of 15 plants, bulb extracts of two plants and rhizome extract of one plant for antifungal activity against *A. triticina*. Among the 18 plants tested *Polyalthia longifolia* gave maximum inhibition (70%) followed by *A. indica*, *O. sanctum*, *C. roscus* and *Zingiber officinalis*. Other plants were least effective. All the sterilized extracts lost activity.

Antimycotic activity of *D. innoxia* extracts against *C. capivar* was reported by Chitra and Kanabiran (2001). Kavitha *et al.* (2001) evaluated leaf extracts of 13 species of *Cassia* against four fungal pathogens. All the plants produced more than 50%
Inhibition in mycelial growth of *A. solani F. oxysporum P. nicotianae* and *Sclerotina rolfsii*

Hakki et al (2002) reported the antifungal effects of glucose derivatives of *Quercus infectoria* against *Alternaria alternata, Candida albicans* etc.

Thoppil (2002) reported antimicrobial activity of essential oil of *Artemisia milguica*, a strongly scented weedy herb of Asteraceae. The oil was toxic to all the six bacteria and seven fungi. *In vitro* antifungal activity of *Tinospora cordifolia* was studied by Britto et al (2002) using chloroform and ethanol extracts. They observed that mycelial growth of both the test fungi was affected and the inhibitory rate increased with increasing concentration. Among the two solvents, chloroform was found to be superior over ethanol.

In our laboratory, several studies were undertaken to bring out the antifungal effect of botanical pesticides and antagonistic microbes (Jasmine, 1997; Senthil Kumar, 1998; Gomathi, 2001; Pugazhenthi, 2001)

Review of the literature shows that most of the studies on antifungal plant extracts were carried out in laboratory conditions. *In vivo* studies are essential while developing new fungicides from plant extracts. Hence the present work has been taken up with the following objectives:

1. To select viable aqueous plant extract showing strong antifungal activity against *C. capsici* by screening

2. To find out the phytotoxicity effects of selected antifungal aqueous plant extract on the seed germination and seedling growth of chilli

3. To investigate physiological alterations in the pathogen by the selected antifungal aqueous plant extract
4. To investigate host pathogen interactions and efficacy of the selected antifungal aqueous plant extract to control anthracnose in the potted conditions.

5. To find out the antifungal active principles present in the selected antifungal aqueous plant extract through partial spectral, chromatographical and phytochemical tests.