Chapter 5

DISCUSSION

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Powdery mildew caused by ascomycetous fungi of the family Erysiphaceae is a causal agent of a serious fungal plant disease on cultivated as well as wild plants. The Erysiphaceae includes 20 genera and more than 400 species (Braun, 1995). A total of 9838 angiosperm plant species of 1617 genera and 169 families are known to be infected by at least one species of powdery mildew (Kunoh, 1995). The powdery mildews are obligately biotrophs that colonize and parasitize green plant tissues. A majority of powdery mildews produced generally develop similar typical symptoms on leaves, stems, and occasionally on the fruits of host plants. Pustules of ectophytic, rarely endophytic mycelium produce conidia and after multiple re-infections, the mycelium can cover the whole surface of the host plants (Yarwood, 1978). Moreover, powdery mildews on plant species regarded as weeds are of potential practical importance because weed can function as alternative host for powdery mildews attacking crop plants and because it has been found that these pathogens have the potential for use as biological control agents to check the menace of weeds. (Kiss, 2003, Rector *et al.* 2006).

Parthenium hysterophorus L. (Asteraceae) is an invasive, exotic and annual herb of necrotropical origin. It was imported accidentally to India along with the PL 480 Mexican wheat seeds in the 1950s and which has become one of the most awful, noxious species of weeds (Rao, 1956). This is also known as congress grass, carrot weed etc. The weed has since grown into uncontrollable proportions invading

millions of hectares of uncultivated wastelands, roadsides, railway tracks and forest etc. This fast growing weed is a nuisance in public parks, residential colonies and orchards. It is also considered a noxious weed because of its allelopathic effect (Kanchan and Jayachandra, 1980; Swaminathan *et al.*, 1990; Adkins and Sowerby, 1996; Sharma *et al.*, 2005; Kumar and Gautam, 2008), strong competitiveness for soil moisture and nutrients, as well as the hazard it poses to humans and animals (Khosla and Sobti, 1979; More *et al.*, 1982; Lakshmi and Srinivas, 2007a; Verma *et al.*, 2006; Srinivas, 2006). Pollens of this weed cause allergenic rhinitis (hey fever) (Lakshmi and Srinivas, 2007b) and may develop finally in bronchitis (asthma). It invades all sorts of crops and herbaceous flora, causing a substantial loss of yield and growth. The major toxicants of *P. hysterophorus* are parthenin and other phenolic acids such as caffeic acid, vanillic acid, ansic acid, chlorogenic acid and parahydroxy benzoic acid, which are lethal to human beings and animals (Mahadevappa, 1997; Oudhia, 1998). This weed has now become an international problem, leading to crop losses in different parts of the globe.

India itself is severely facing the problem of reduced crop yield and also loss of many important plants due to invasive behaviors of this weed. Yield decline was recorded upto 40% in agricultural crops (Khosla and Sobti, 1981), while a significant reduction up to 90% has been reported in case of forage production in grassland (Nath, 1988). Most Caribbean countries bear about 20% (average) crop yield loss only due to this weed. Due to more tolerance capacity of this weed against widely used herbicides such as paraquet, atrazine, 2, 4-D, metribuzin,

trifluralin, diphenamid, it ranks fourth most serious weed of crops (Hammerton, 1981; Singh *et al.*, 2004). It is reported to be one of the most important and damaging weeds to the Coffee plants in Kenya (Njoroge, 1986).

Jayachandra (1971) reported that this weed can be a serious problem for grassland in India, which can reduce the pasture carrying capacity severely up to 90%. Serious human health risks due to *P. hysterophorus* had been reported in India, about three decades ago (Srinivas, 2005; Handa *et al.,* 2001; Dhileepan *et al.*, 2000; Chippendale and Panetta, 1994; Lonkar *et al.*, 1974).

The present study was carried out with the aim to investigate the effect of a fungal bio-control agent *E. cichoracearum* on *P. hysterophorus* to avoid adverse effects of chemical herbicides (Caroline *et al.*, 2001) and to find out an alternative measure to manage this weed. A biological control can play a significant role to check the growth of *P. hysterophorus* weed because of its sustainability, cost effectiveness and eco-friendly nature (Evans, 1997). In search of effective and safe biological control agent for this hazardous and dangerous weed, several agencies of the Indian government are involved in monitoring the research programmes at different centers exclusively dealing with this problem because chemical control has its own drawbacks which may degrade the air quality.

Government of India has also decided to import a Mexican beetle (*Carmenta ithaca*) a stem borer moth which feed on *P. hysterophorus* stem (Yaduraja, 2005). Since, that insect is effective against *P. hysterophorus* in different climatic conditions therefore, prediction about their effectiveness in our country may be little

premature and search of an effective indigenous bio-control agent against this weed may always be on high demand which could work efficiently in local environment.

The *P. hysterophorus* infected with either *E. cichoracearum* var. *cichoracearum* (Figs. 1,3 and 4) or *S. fuliginea* (Fig. 2) showed typical powdery mildew symptoms, which first appeared as white-powdered colonies that subsequently coalesced covering the entire leaf surface. Severe infections caused leaf distortion, withering and premature senescence. Tiny black fruiting bodies of the overwintering stage developed in mildew growth of both the fungi. The species identification was based on Braun's monographs (Braun 1987, 1995) and findings of some other workers (Sohi and Nayar 1969, Khodaparast *et al.* 2001, Shin 2000, Braun *et al.*2002, 2006; Takamatsu *et al.* 2007; Braun & Minnis 2008).

The charactristic features of anamorphic and teliomorphic states of *E. cichoracearum* var. *cichoracearum* infecting *P. hysterophorus* were more or less similar as reported earliar by Braun (1987 and 1995), Khan and Sharma (1995), Braun *et al.* (2002) and Paul and Thakur (2006). Similarly, the charactristic features of anamorphic and teliomorphic states *S. fuliginea* were almost similar to those described earlier by Jhooty (1967), Sohi and Nayar (1969) and Khan and Sharma (1995). Therfore, it can be concluded from the present results that the powdery mildew diseases of *P. hysterophorus* was caused by *E. cichoracearum* var. *cichoracearum* and *S. fuliginea.* Scanning of literature revealed that both the powdery mildew diseases of *P. hysterophorus* were reported, for the first time from

Uttar Pradesh. Moreover, these diseases have also been reported earlier from other states of India.

The powdery mildew disease of *P. hysterophorus* caused by *E. cichoracearum* var. *cichoracearum* and *S. fuliginea* has been reported from Jabalpur (M.P.) and Poona (M.S.) by Patel and Sharma (1996) and Patwardhan (1966), respectively. Besides, the powdery mildew disease of *P. hysterophorus* caused by *Oidium parthenii* has also been reported from Hyderabad, A.P. (Prashad and Rani, 1981).

The anamorphic charectristic features of the powdery mildew fungus infecting different weeds viz., *Parthenium hysterophorus, Acalypha indica, Ageratum conyzoides, Cissampelos pareira, Coccinia cardifolia, Euphorbia hirta, Melilotus indica, Solanum nigrum* and *Vernonia cineria* is more or less similar to that of *E. cichoracearum* var. *cichoracearum* as reported earlier by Braun (1987), Braun *et al.* (2002), Khan and Sharma (1971) and Paul and Thakur (2006). Therefore, it can be concluded from the results that powdery mildew disease of these weeds was caused by *E. cichoracearum* var. *cichoracearum.*

During the survey of powdery mildew diseases of weeds, only the anamorphic state of *Erysiphe cichoracearum* var. *cichoracearum* was observed on some weeds infected with this fungus. The national status of powdery mildew disease of these weeds caused by *E. cichoracearum* is given below:

Coccinia cardifolia- The infection of *Erysiphe cichoracearum* on *C. cordifolia* has also been reported from Poona, M.S. (Uppal *et al.* 1935), Allahabad, U.P. (Mittal and Tondon 1930), Kanpur, U.P. (Butlar and Bisby 1931), and Aligarh, U.P. (Khan

and Akram 1972). Similarly, the powdery mildew disease caused by *Erysiphe orontii* on *Coccinia* sp. has already been reported from Hyderabad A.P. (Bhagyanarayana 1988) and Jabalpur, M.P. (Sharma and Khare 1992).

Melilotus indica-The powdery mildew disease of *M. indica* caused by *Erysiphe polygoni* has been reported from Pusa, Bihar (Agarwal *et al.* 1959).

Solanum nigrum- The infection of *Leveillula taurica* on *S. nigrum* has been reported from Rajasthan (Mathur *et al.* 1971).

Euphorbia hirta- The infection of *Sphaerotheca fuliginea* and *Sphaerotheca euphorbiae* on *E. hirta* has been reported from Akola, M.S. (Swami, *et al.* 1976) and Hyderabad, A.P. (Rao, 1961), respectively. Moreover, the infection of powdery mildew fungus *Erysiphe polygoni* on *E. hirta* has been reported from Dharmad. India (Kunkalikar 1914).

Vernonia cineria - The infection of *E. cichoracearum* on *V. cineria* has already been reported from Aligarh U.P. (Parwez and Akram, 1987) but they did not mention the variety of *E. cichoracearum.* Powdery mildew disease caused by other genera viz., *Oidium vernoniae* and *Leveillula taurica* has been reported from Chambaghat M.P. (Paul and Munjal 1982) and Jobner Rajasthan (Maharshi 1984) respectively.

Acalypha indica- The infection of *Erysiphe acalyphae* on *A. indica* has been reported from Rajendranagar A.P. (Bhagyanarayna *et al.* 1988).

Ageratum conyzoides- Patel and Sharma (1986) and Kamal *et al.* (1977) reported the powdery mildew disease of *A. conyzoides* caused by *E. cichoracearum* from Shivpurva Rewa M.P. and *Oidium argentii* from Gorakhpur U.P. (Kamal *et al.* 1977).

Cissampelos pareira- The powdery mildew disease of *Cissampelos pareira* so far has not been reported from India as well as abroad.

The scanning of literature revealed that out of eight weeds, the powdery mildew disease of five weeds viz., *Solanum nigrum, Euphorbia hirta, Cissampelos pareira, Melilotus indica* and *Acalypha indica* caused by *E. cichoracearum* var. *cichoracearum* has been reported for the first time from India, whereas, the powdery mildew disease, caused by this fungus on *A. conyzoides* is a new report from Utter Pradesh.

The powdery mildew disease of *P. hysterophorus* caused by *Erysiphe cichoracearum* var. *cichoracearum* was found from the month of February to April in all the five localities of Aligarh viz., AMU campus, Mathura road, Agra road, Dhurra and University fort. Moreover, the maximum frequency of occurrence and intensity of the disease (+++) was recorded in the month of March followed by April and February. Similarly, the infection of powdery mildew fungus *Sphaerotheca fuliginea* on *P. hysterophorus* was found in the month of January to April only in two localities of Aligarh viz., Mathura road and Agra road. Moreover, *S. fuliginea* showed moderate to mild infection on *P. hysterophorus.*

Discussion

The symptoms of powdery mildew disease caused by *E. cichoracearum* var. *cichoracearum* first appeared in the month of January on *Ageratum conyzoides* and *Euphorbia hirta,* on *Solanum nigrum, Acalypha indica* and *Vernonia cineria* in February, in March on *Melilotus indica,* in November on *Coccinia cardifolia* and in December on *Cissampelos pareira.*

The severe infection of powdery mildew disease caused by *E. cichoracearum* var. *cichoracearum* on *Acalypha indica* and *Vernonia cineria* was observed in the month of March, whereas, in the month of February it was recorded on *Ageratum conyzoides* and *Euphorbia hirta.* Similarly, the severe infection of powdery mildew disease of *Cissampelos pareira* and *Coccinia cardifolia* was recorded in the month of January and February.

It can be concluded from the above results that the intensity and frequency of occurrence of powdery mildew disease varied on different weeds including *P. hysterophorus.* Similarly, the anamorphic characteristic features (viz., dimension of conidia and conidiophores, length of foot cell and number of septa/conidiophores) of *E. cichoracearum* var. *cichoracearum* samples collected from different weeds also showed slight variation in their measurements. These results are also in agreement with those of Khan *et al.* (1977), Hussain and Akram (1997), Pawar *et al.* (2009) and Chauhan *et al.* (2010). Powdery mildew is more prevalent in Aligarh during November to April. With the onset of summer, they begin to disappear and are absent during the summer and rainy season. They reappear after the rainy season is over. The species of the Erysiphaceae were recorded on different host with

varying intensities (Khan *et al.* 1977). Hussain and Akram (1997) demonstrated a high incidence and intensity of powdery mildew disease caused by *E. cichoracearum* and *S. fuliginea* on ornamental crops grown in Aligarh. The potential of these species to attack composites, in general, cannot be ignored and should be considered in disease management strategies. Pawar *et al.* (2009) reported that the cucurbit powdery mildew in the state of Maharashtra in Jalgaon district was prevalent throughout the region on ten cultivated and two wild *Coccinia cordifolia* and *Coccinia indica* cucurbits wich were encountered during the survey. Ten cultivated and the two wild species were found to be infected with the fungus. The disease was more severe during March to May and September to November, mild to moderate during December to February and altogether absent during June to August. Perithecia of *Erysiphe cichoracearum*, were observed during December to February only in *Coccinia cordifolia*, *Citrullus lanatus* and *Citrullus fishtulosus.*

In the present finding, the maximum frequency of occurrence and severe infection were observed from the month of January to March which is understandable as during these periods the temperature ranges between 21-31^{0}C and relative humidity is between 49-72% which are favourable for its development as also reported by Schnathorst (1965) and Yarwood (1957). Teliomorph of *E. cichoracearum* was not found in other weeds except *P. hysterophorus*. It might be due to the absence of tow sexually compatible strains and presence of only one mating type of the species. However, the influence of various environmental conditions on perithecial development cannot be ruled out.

The inoculation of *E. cichoracearum* var. *cichoracearum* and *S. fuliginea* on *P. hysterophorus* caused significant reduction in plant growth parameters (length of plant, fresh and dry weight of plant, number of head/plant, viability of pollen grain and germination of seeds) as compared to un-inoculated plants (control). Moreover, the greatest reduction in plant growth parameters was caused by *E. cichoracearum* var. *cichoracearum* as compared to *S. fuliginea.* These finding are also in agreement with those of Bakshi *et al.* (1972), Khan *et al.* (1976), Phillip *et al.* (1994), Tiwari *et al.* (1997), Tang *et al.* (2006) and Chauhan *et al.* (2010). Powdery mildew of cucurbits caused by *E. cichoracearum* and *S. fuliginea* are the major limiting factor in cucurbit cultivation in India (Khan *et al.* 1976). Bakshi *et al.* (1972) reported that the *Phyllactinia corylea* infects mulberry leaves and reduces not only yield but also nutritional value, thus making the leaves unsuitable for silkworm feeding. Similarly, moisture, ash, lipid, crude fibre, carbohydrate, vitamins and minerals contents were decreased significantly after infection of mulberry leaves with fungus, *Phyllactinia corylea* (Tang *et al.,* 2006). *Erysiphe pisi* causes powdery mildew on pea and adversely affected the total biomass yield, number of pod per plant, number of seed per plant and plant height (Gritten and Ebert, 1975). Munjal *et al.* (1963) and Reiling (1984) found that the severe infection of powdery mildew disease on pea may result in 25% to 50% yield reduction.

Therefore, it can be concluded from the above results that both of the powdery mildew fungi *E. cichoracearum* var. *cichoracearum* and *S. fuliginea* as floral heads and leaves pathogen inhibited growth and development of leaves and

heads. In due course of time, it might have affected pollen and/or embryo development leading to sterile seed formation. Infection of *E. cichoracearum* var. *cichoracearum* and *S. fuliginea* have deleterious effects on *P. hysterophorus* weed only, and not to other economically important plant species, which live together under same niche, however, detailed study on their host range needs further attention. Due to invasive nature and luxuriant growth of *P. hysterophorus* in different habitat, both the powdery mildews as a floral and leaf pathogen may be used as a potential mycoherbicide against this weed. Use of the powdery mildew fungi as biological control can play a significant role to check the growth of *P. hysterophorus* weed because of its sustainability, cost effectiveness and ecofriendly nature.