J. Mycopathol. Res. **44**(2) : 253-256 (2006)

A report on powdery mildew infestations caused by *Erysiphe polygoni* D.C. in North American grown fenugreek

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Powdery mildew caused by *Erysiphe polygoni* D.C. is one of the serious diseases affecting biomass and seed yield of fenugreek (*Trigonella foenum-graecum* L.) under moist agro-climatic conditions in North America, such as Creston in British Columbia (Canada) and in Vermont (USA). Our two year study (2004-2005) under varied agro-climatic conditions investigated fungal infestation pattern and identified growth parameters for *E. polygoni* under North American growing conditions. The growth of the fungus was vigorous under moist and warm growing conditions and could prove to be detrimental in fenugreek production in this area.

Key words : Fenugreek, *Trigonella foenum-graecum* L., Tristar, powdery mildew, *Erysiphe polygoni* D.C., Canada, USA

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L.,) is a natural steroid rich, bloat-free, dryland preferring, annual forage legume, native to Mediterranean Europe but also grows in south Asia, northern Africa, and recently in the Americas and in Australia (Acharya *et al.*, 2006). Tristar is the first North American fenugreek forage cultivar released in 2004 for commercial seed production by the Agriculture and Agri-Food Canada Lethbridge Research Centre (Basu *et al.*, 2005). This cultivar has been found to be susceptible to powdery mildew caused by *Erysiphe polygoni* D.C. under moist growing conditions. This pathogen is a member of the family Ascomycotina and has been reported to be one of the most important diseases affecting fenugreek seed and forage yield in hot and humid tropical countries like India (Prakash and Saharan 2000). Powdery mildew on fenugreek has also been reported from other subtropical and temperate countries like Mediterranean Europe, northern Africa, Australia and United Kingdom (Jongebloed 2004; Petropoulos 2002). However, there has been no report of powdery mildew infections on fenugreek from North America as it is a newly introduced crop to this area. From our observations under greenhouse and field conditions we feel that it has the potential to become one of the serious fungal diseases affecting fenugreek in North America.

MATERIALS AND METHODS

For this study five fenugreek genotypes (F70, F80, F86, Tristar and Amber) were used. Each plot consisted of 10 rows (18 cm apart) and was 1.8 × 6 m^2 in size. The plots were arranged as in five times replicated Randomized Complete Block Design in each environment. The environments included rain-fed and irrigation (50 mm × 4) conditions (2004 & 2005) in Lethbridge (Alberta), Creston (British Columbia) and Vermont (U.S.A.). The seeding rate for each line in all of the environments was 15 kg

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ha^{-1}. The plots were seeded using a 1972 built 10-row forage seeder with 2.5 cm depth bands and packers (REM MFG. LTD, Swift Current, SK) in the second week of May and harvested in the first week of October with the Hege 212 forage harvester with a Harvest Master weighting system — 1.25 m cutting width. The fungicides used were Tilt 250 E-propiconazole (Ciba-Geigy) or Milgo-Ethrinol 28 % (Imperial Chemical Industries) @ 2.5 ml L^{-1} and ; Captan-Captane 50 % (United Agri Products) or Benlate-Benomyl 50 % (Du Point) @ 2.0 g L^{-1}. The plants were dried for a week indoor before seeds were separated from the plants and yield was determined. Random samples were procured from infected plants before harvest each year, slide mounts were prepared using Lactophenol-Cotton blue mix (Sigma Aldrich) and the mycelia and conidiophores of the fungal specimens were observed using a standard laboratory hand lens and in a compound microscope (eye piece –10X WF ; objective –160/A10/0.25 ; Numerical Aperture (NA) of 0.9 ; Olympus® Japan). All measurements were done using a microscopic enumerator NHWK 10X/20L (Olympus® Japan). The specimens were identified using Dugan (2006) key for North American fungi. Scanning Electron Microscopic (SEM) study using Hitachi-S570 was conducted following a SEM protocol described in Basu (2006). All photographs were taken using a Nikkon Coolpix 3200.

RESULTS AND DISCUSSION

The conditions such as high relative humidity (95-97 %), overcast weather, warmer days and cooler nights, within a temperature range of 23-30°C, and high annual precipitation (above 350-400 mm) resulted in an outbreak of powdery mildew on fenugreek in western Canada and eastern USA. The severity of the disease was found to be higher in Creston in the province of British Columbia (BC), in the western part of Canada and Vermont in the eastern part of the North American continent, both of which possessed a moist and humid environment compared to the relatively dry weather conditions of Lethbridge in southern Alberta (part of the western Canada prairies) in 2004. Powdery mildew infections were observed both in our greenhouse studies (Fig. 1) as well as for plants grown under field conditions (both rain-fed and irrigated) in 2005 at Lethbridge when moisture conditions were more conducive to infection of the plants.

Fig. 1 : A powdery mildew infected fenugreek plant in the LRC greenhouse, Lethbridge, AB, Canada.

Presence of powdery mildew on plants grown under greenhouse conditions was difficult to eradicate and resulted in serious loss in plant biomass and seed yield. However, our study indicated that application of Tilt 250E-propiconazole (Ciba-Geigy) or Milgo-Ethrinol 28 % (Imperial Chemical Industries) @ 2.5 ml L^{-1} and; Captan-Captane 50 % (United Agri Products) or Benlate-Benomyl 50 % (Du Pont) @ 2.0 gm L^{-1} were successful in controlling greenhouse infections at Lethbridge in both years. Symptoms of plant infection included white to gray powdery masses or distinct circular to ellipsoidal patches which varied in length from 1.5–2.5 cm on the stem (at an advanced stage), both surfaces of the leaves, pods and occasionally on the flowers. Leaves close to the ground were infected first after which, it soon covered the whole plant. Severe infection of the leaves resulted in a dry and

shriveled appearance which stimulated early senescence and severely reduced plant growth. The upper surface of the leaves showed a higher load of mycelium and spores than the bottom surface. Plants grown under shade conditions exhibited more serious infections compared to those exposed to sunlight under field conditions. Severely infected leaves were irregular in shape and plants were stunted in growth. These plants emitted a strong odor characteristic of this fungal infection. Powdery mildew exposes crops to secondary infections by other fungi further reducing yield (Agrios 1997).

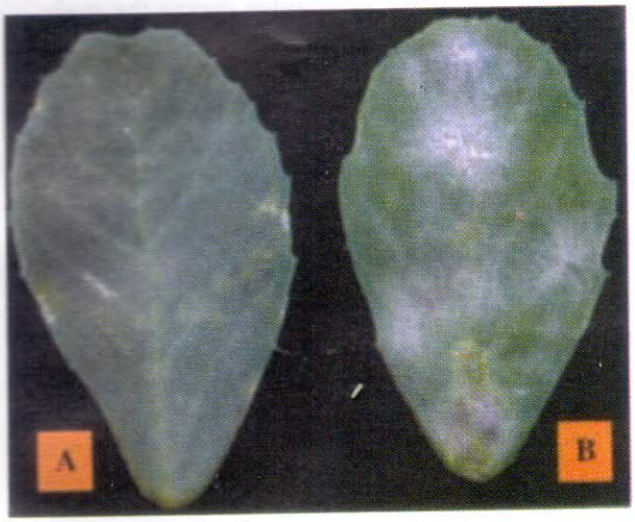

Fig. 2 : A. Dorsal surface of a healthy fenugreek leaf; and B. Dorsal surface of fenugreek leaf infected with powdery mildew.

Fungal patches appeared isolated or in scattered patches in the initial stage of infection but coalesced during advanced stages of infection (Fig. 2). Conidia were produced in chains on simple, erect conidiophores. Individual conidia were ellipsoidal to cylindrical in shape, septate, single-celled and appeared hyaline or colorless (Fig 3 A-C). The conidiophores varied from 32.5-65.6 µm X 9.7-13.6 µm; whereas the dimensions for the conidia were 22.6-48.4 µm X 12.4-20.8 µm. Both the mycelia and conidiophores were produced on the plant surface and, were easily observed under a hand lens (5 X) and with a low power objective (10 X) using an ordinary Olympus compound microscope.

A Scanning Electron Microscopic (SEM) study using a Hitachi-S570 indicated that the mycelium and conidiophores traverse the leaf surfaces in a

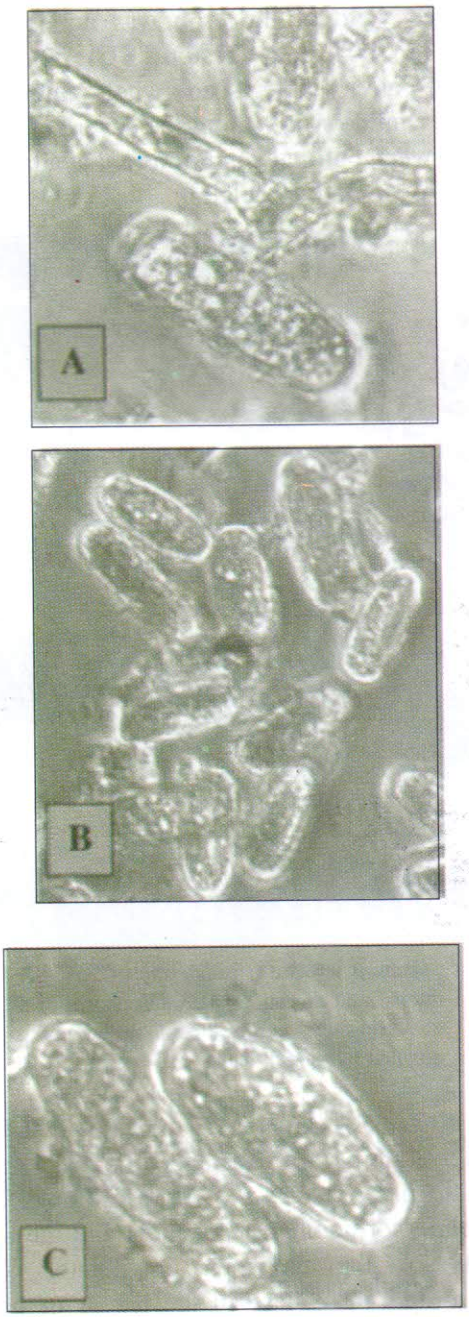

Fig. 3 : A. Hyaline and ellipsoidal conidium attached to the elongated and cylindrical conidiophore of *E. polygoni*; B. Aggregation of conidia; and C. Enlarged view of the conidia of *E. polygoni*.

reticulate manner (Fig. 4).The optimal temperature for conidial germination of *Erysiphe polygoni* D.C. has been reported to be 21°C (Prakash an Saharan 2000). In Creston (BC) a temperature of 21-22°C was observed during the growing season and may have been a factor in conidial germination of this fungus. At this location a severe reduction in forage

and seed yield of the crop was noticed in both years. In 2004, the Creston (BC) plots did not produce any viable seed when infected with powdery mildew indicating the severe effect of the fungus when optimal conditions are available for its rapid growth and sporulation.

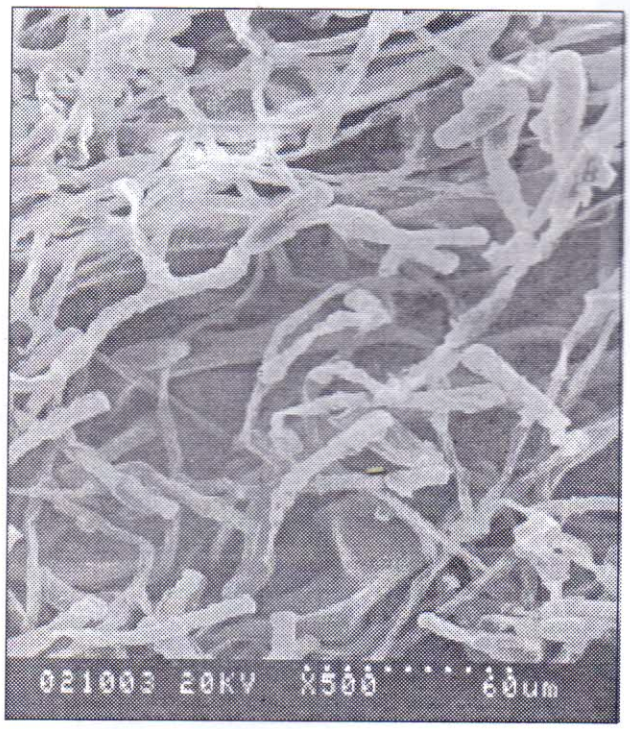

Fig. 4 : Scanning electron micrograph (X 500) showing intertwined mycelia and conidiophores of *E. polygoni* traversing the entire dorsal surface of a severely infected fenugreek leaf.

Interestingly a recent report indicates that there is genetic variability for resistance to powdery mildew in fenugreek (Avtar *et al.*, 2003). The total content of phenols, orthodihydric phenols and the specific activity of the enzymes polyphenol oxidase, catalase and peroxidase in the leaves of powdery mildew resistant fenugreek cultivars were higher than those seen in susceptible genotypes. However, in more severely infected plants levels of polyphenol oxidase and peroxidase were found to be higher in susceptible cultivars compared to resistant ones. These measurements may help with development of resistant fenugreek cultivars for North America.

ACKNOWLEDGEMENT

Financial assistance for this study was partly provided by the Alberta Agricultural Research Institute, Farming for the Future Program and the School of Graduate Studies, University of Lethbridge in the form of a Student Assistantship. We also acknowledge the help of Dr. Heather Darby of University of Vermont, USA, Mr. Doug Friebel, Forage Technician and Mr. Byron Lee, Research Technician, Electron Microscopy and Image Analysis Laboratory at the Agriculture and Agri-Food Canada, Lethbridge during the study.

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(Accepted for publication April 10 2006)