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Effect of leaf rust infection on mycorrhizal colonization of weeds

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Abstract

The present study reports the effect of leaf rusts *Puccinia punctiformis* (Str.) Röhl., *Melampsora euphorbiae* (Schub.) Cast. and *Uromyces rumicis* (Schum.) Winter, on arbuscular mycorrhizal (AM) colonization of host weeds namely *Cirsium arvense* (L.) Scop., *Euphorbia helioscopia* L. and *Rumex dentatus* L., respectively. Healthy, moderately infected and severely infected plants of these test species were collected at flowering stage. Mycelial colonization was recorded in terms of percentage on the bases of presence and absence of these structures. Arbuscular and vesicular colonization were quantified by counting these structures per centimeter of root length on an average. Mycelial colonization was not significantly affected by disease in any of the three test species. There was very heavy colonization ranging from 90–100% in different healthy and diseased root samples. Response of arbuscular colonization to rust infection was variable with respect to host species. In both *C. arvense* and *E. helioscopia* effect of moderate rust infection was insignificant. Heavy disease infection significantly suppressed the number of arbuscules in *C. ravens* and increased in *E. helioscopia*. Conversely, in *R. dentatus* moderate rust infection significantly enhanced the number of arbuscules while heavy infection completely arrested the formation of these structures. Vesicular colonization was significantly enhanced by heavy infection in *C. arvense* while in *E. helioscopia* both moderate and heavy infections significantly reduced the number of arbuscules. In *R. dentatus* vesicular colonization was entirely lacking.

Key words: Leaf rust, weeds, arbuscular mycorrhizae, AM fungi.

Introduction

Arbuscular mycorrhizal (AM) fungi are ubiquitous soil inhabitants forming symbiosis with most naturally growing terrestrial (Jeffries, 1987; Muthukumar and Udaiyan, 2000) and aquatic (Khan & Belik, 1995) plants. They also predominate in roots and soils of agricultural crops (Trappe, 1987). These fungi are associated with 80% of the plant families in the world (Giovannetti & Sbrana, 1998). Colonization of roots by mycorrhizal fungi has been shown to improve growth and productivity of several field crops including legumes, cereals, vegetables and oil crops (Javaid *et al*., 1994, Yao *et al.*, 2002, Kapoor *et al.*, 2004; Subramanian *et al*., 2006, Wang *et al.*, 2006). Mycorrhizal associations increase plant growth and productivity by increasing nutrient element uptake (Al-Karaki, 2002) and improving resistance to abiotic (Feng *et al*., 2002; Chen *et al*., 2006) and biotic (St. Arnaud *et al*., 1994) stress factors.

Many reports in the literature indicate that mycorrhizal fungi decrease disease severity (Lingua *et al*., 2002; de la Pena *et al*., 2006). Resistance and tolerance against plant pathogens due to mycorrhizal inoculation could be due to morphological alterations such as thickening of cell wall through lignification and production of other polysaccharides in mycorrhizal plants (Becker, 1976). Alteration in the severity of plant disease in mycorrhizal plants may also be attributed to physiological and biochemical changes in the host induced by the mycorrhizal fungi (Abdul-Fattah & Shabana, 2002; Hao *et al*., 2005). The formation, development and functioning of AM is also influenced both by abiotic as well as biotic stress factors (Malcova *et al*., 2002; Akkopru & Demir, 2005). The present study reports the effect of leaf rust on formation of AM in three weed species namely *Cirsium arvense*, *Euphorbia helioscopia* and *Rumex dentatus*.

Materials and Methods

Sampling of weeds

Sampling of the three test weeds species viz. *Cirsium arvense*, *E. heleoscopia* and *R. dentatus* infected with rust fungi namely *P. punctiformis*, *M. euphorbiae* and *U. rumicis*, was carried out from Quaid-e-Azam Campus, University of the Punjab Lahore during March-April 2006. For each of the three weed species, plants of three categories

viz. healthy, moderately infected and severely infected were collected. Six plants of each category at flowering stage were carefully uprooted. Fine roots were separated from the main roots and were cut into small pieces of 1 cm.

Clearing and staining of roots

After careful rinsing with tap water, the root samples were cleared and stained for analysis of colonization by mycorrhizal fungi using Phillips and Hayman (1970) procedure. The roots were cleared for about 30 minutes in 10% KOH solution in an autoclave, placed in 10% HCl for 10 minutes for neutralization and then stained with glycerol-trypan blue solution (0.05%).

Mycorrhizal study

Randomly selected, 30 root pieces of 1 cm each were mounted in lactophenol and studied for each plant sample under compound microscope. For percentage mycelial infection each root piece was observed at 5 points under 10x power of a compound microscope. Arbuscular and vesicular infections were quantified by counting these structures per cm of root length.

Statistical analysis:

All the data were analyzed by applying Duncan's Multiple Range Test (Steel & Torrie, 1980).

Results and Discussion

Effect of leaf rust on mycelial colonization

Mycelial colonization in healthy plants of all the three test weeds was very high i.e. ranged fro 90–100 %. No pronounced effect of either moderate or heavy rust infections on this studied parameter was observed in any of the test weed species (Fig. 1A).

Effect of leaf rust on arbuscular colonization

Arbuscules are functional haustoria like structures formed within the root cortical cells. These are the sites of bilateral exchange of metabolites between fungus and host cytoplasm (Bethlenfalvay & Linderman, 1992). In the present study a variable response of arbuscular infection to leaf rust infection was observed with respect to test host species. In *C. arvense*, affect of moderate infection was insignificant while heavy infection caused significant suppression in the number of arbuscules. In *E. helioscopia* generally arbuscular infection was low. Moderate rust infection exhibited insignificant effect while heavy infection significantly enhanced the number of arbuscules. Conversely in *R. dentatus* moderate infection significantly increased the number of arbuscules while heavy infection completely arrested the formation of these structures (Fig. 1B). During rust infection, there are major changes in the intermediate metabolism of the host. In many cases these metabolic transitions have been correlated with the formation of enzymes and isoenzymes, kinetic and catalytic properties of which are markedly different from enzymes of the healthy plants (Chakravarty & Scott, 1982). In the present study, the selected angiospermic weed species were infected by three different rust genera namely *Puccinia*, *Uromyces* and *Melampsora*. The variable response exhibited in terms of arbuscular infection probably can be attributed to species specific metabolic dynamics in case of diseases.

Effect of leaf rust on vesicular colonization

Vesicles usually form in root cortical cells and function as nutrient storage organs or as propagules in root fragments (Bethlenfalvay & Linderman, 1992). Similar to that of arbuscular colonization, response of vesicular colonization to rust attack was also host species specific. In *C. arvense* moderate rust infection did not show any pronounced effect while heavy infection significantly enhanced the number of arbuscules. In contrast to that there was a significant reduction in vesicular number in *E. helioscopia* due to moderate as well as heavy rust infections. These different responses of vesicular colonization may be attributed to different metabolites formation in response to different rust fungi. In *R. dentatus* vesicular colonization was entirely lacking (Fig. 1C). It has been reported earlier that some of the fungi that form mycorrhizas with arbuscules do not produce vesicles, hence a more generalized term "arbuscular mycorrhiza (AM)" than VAM (vesicular arbuscular mycorrhizae) is being used for these fungi now a days (Walker, 1995).

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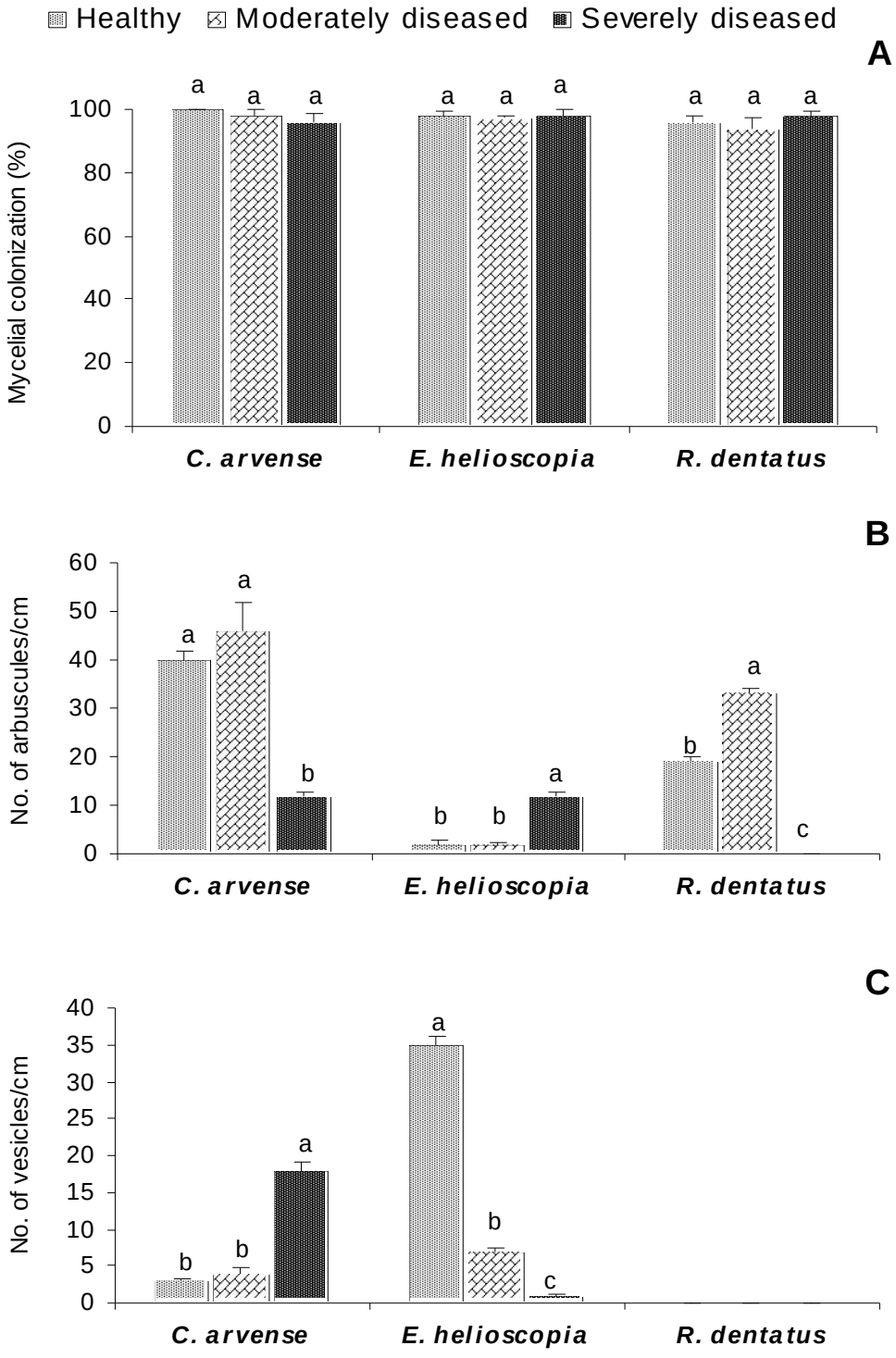

Fig. 1: Effect of leaf rust on arbuscular mycorrhizal colonization of weeds. Vertical bars show standard error of means of three replicates. Values with different letters show significant difference (P = 0.05) as determined by DMR Test

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