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Short communication

Responses of some different pepper (*Capsicum annuum* L.) genotypes to inoculation with two different arbuscular mycorrhizal fungi

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Abstract

Eight different pepper genotypes inoculated by two different arbuscular mycorrhizal fungi (AMF) [*Glomus intraradices* (*Gi*) and *Gigaspora margarita* (*Gm*)] in a growth chamber experiment under normal seedling growing conditions were evaluated for seedling traits, colonization and relative mycorrhizal dependency (RMD). In general, inoculated plants had greater dry weights compared to non-inoculated plants. Five cultivars responded positively to inoculation with AM fungi and three responded negatively. A great variation in mycorrhizal colonization dependency was observed among the pepper genotypes, with the N52 genotype showing the highest RMD and the Karaisali genotype the lowest. RMD and dry weights of pepper genotypes were inversely correlated.

Keywords: Arbuscular mycorrhizae; Genotypes; Growth; Pepper; Responsiveness; Symbiosis

1. Introduction

Arbuscular mycorrhizal fungi (AMF) are the most widespread root fungal symbionts and are associated with the vast majority of higher plants. AMF have been shown to improve soil structure (Miller and Jastrow, 2000), and their high capacity to increase plant growth and yield by improving plant nutrient uptake gives them great importance (Smith and Read, 1997). AMF also enable plants to cope with both biotic and abiotic stresses: they may help fight off verticillium wilt (Garmendia et al., 2004), alleviate certain nutrient deficiencies, improve drought tolerance, overcome the detrimental effects of salinity and enhance tolerance to pollution (Brundrett, 1991; Declerck et al., 1995; Turkmen et al., 2005).

Pepper (*Capsicum annuum* L.) is an important vegetable in Turkey and in the world (FAOSTAT, 2006). Recent studies have suggested that AMF-inoculated pepper could benefit from association with AMF (Davies et al., 2002; Salami, 2002; Demir, 2004; Garmendia et al., 2004; Turkmen et al., 2005). Differences in mycorrhizal responsiveness between different crops and between different genotypes within the same crop have also been demonstrated (Declerck et al., 1995; Parke and Kaeppler, 2000; Linderman and Davis, 2004). Linderman and Davis (2004) have shown this clearly in their study of different marigold genotypes and AMF, as have Declerck et al. (1995) in their work with bananas and AMF. The effectiveness of different AMF on different pepper genotypes has not been well documented, even under normal seedling conditions. Therefore, the present study aimed to evaluate colonization, responsiveness and some seedling traits of eight pepper genotypes with different fruit characteristics and origins inoculated by two different AMF under normal seedling growing conditions.

2. Materials and methods

Eight pepper genotypes with different fruit characteristics or origins were examined, as follows: (1) Karaisali: a locally produced hot long red pepper grown for paste in Turkey; (2) N52: a hot long green pepper accession; (3) Hatay Ince Sivri and (4) Alata 42: sweet long green peppers grown in Turkey; (5) Demre: a widely produced sweet long green pepper cultivar grown in Turkey; (6) Kandil: a widely produced sweet green bell pepper cultivar grown in Turkey; (7) Serrano Chili and (8) Cayenne Long Slim: small hot new world varieties (Anon., 2007).

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Two AMF inoculums were tested in the study—*Glomus intraradices* (*Gi*) and *Gigaspora margarita* (*Gm*). Inocula consisted of spores, extraradical mycelium and mycorrhizal roots.

Growth medium was comprised of an autoclaved mixture of sand, manure and soil with a pH of 8.36 and a composition of 6.61% organic matter, 0.014% salt, 8.70% lime, 0.441% nitrogen, 39 ppm phosphorous (Olsen) and 250 ppm potassium. Soil characteristics were analyzed using the Association of Official Analytical Chemists' methods (Helrich, 1990).

The experiment used an 8×3 factorial design (eight pepper genotypes, two AMF plus one control) with three random replications of eight pots (no drainage) each, for a total of 576 pots. Three pepper seeds were sown per pot, each of which contained 250 cm^3 of sterilized growth medium. In the AMF-inoculated samples, 5 g (25 spores g^{-1}) of inoculum was placed in the growth medium before the seeds were sown (Demir and Onoğur, 1999). Seedlings were thinned to one per pot shortly after seed emergence, placed in a growth chamber at a temperature of 22 ± 1 °C with 12 h fluorescent illumination (8000 lx light intensity), and irrigated with distilled water. Plants were harvested 9 weeks after seed sowing and inoculation.

Shoot dry weights (SDW) and root dry weights (RDW) of seedlings were determined after harvesting. Samples were then oven-dried at 68 °C for 48 h, ground, and phosphorous (P) content of both shoots and roots measured using the vanadate-molybdate-yellow procedure with spectrophotometer (Kacar, 1984).

Pepper roots were dyed to detect AMF presence, which was determined using a modification of Phillips and Hayman's (1970) method, and the percentage and intensity of mycorrhizal colonization was estimated using the Grid Line Intersect Method (Giovanetti and Mosse, 1980). Intraradical colonization and extraradical hyphae development were determined using an intensity rating system for structures (arbuscules, vesicles, internal hyphae, external hyphae), as follows: (0) structures absent; (1) present but scarce; (2) abundant throughout root piece; (3) densely packed throughout root piece (Linderman and Davis, 2004).

Relative mycorrhizal dependency (RMD) of pepper genotypes was expressed as the difference between the dry weight of the mycorrhizal plant and the dry weight of the non-mycorrhizal plant as a percentage of the dry weight of the mycorrhizal plant (Declerck et al., 1995).

Data were analyzed using the SAS statistical program, with variance analysis conducted for all data. Differences between treatments were determined using Duncan's Multiple Range Test (SAS Software, 1997).

3. Results

The SDWs and RDWs of both the *Gi*- and *Gm*-inoculated N52 pepper genotype were significantly higher ($P < 0.01$) than the N52 control group (Table 1). The SDW and RDW of the *Gm*-inoculated cv. Demre were also significantly ($P < 0.01$) higher than the cv. Demre control group. Conversely, the SDW was significantly lower ($P < 0.05$) in the *Gm*-inoculated Karaisali genotype, as were the RDWs of both the *Gm*-inoculated Karaisali ($P < 0.01$) and the *Gm*-inoculated Alata 42 ($P < 0.05$) when compared to the controls. No significant differences in SDWs or RDWs were observed in the other four pepper genotypes tested. Total DWs exhibited trends similar to those of the SDWs (Table 1).

There were no significant differences in root or shoot P contents among pepper genotypes at the end of the study (Table 2). The AMF did not cause significant increases in P content when compared to controls because of the adequate levels of P in the growing medium.

The extent of root colonization varied among the genotype-AMF combinations tested (Table 3). Root colonization of *Gm* was the highest for Alata 52 followed by N52, the lowest for Hatay IS followed by Karaisali ($P < 0.05$). On the other hand, root colonization of *Gi* was the highest for Hatay IS followed by N52 and Kandil; the lowest for Serrano C followed by Cayenne LS ($P < 0.05$). It was also noticed that *Gm* colonization was higher than *Gi* colonization in the Alata 52 and Serrano C genotypes, whereas *Gi* colonization was higher than *Gm* colonization in the Hatay IS genotype.

Root colonization intensity varied among the genotype-AMF combinations, with vesicular formations ranging from scarce to dense. Internal hyphae formation was present, but scarce, with *Gm*-inoculated Karaisali and *Gi*-inoculated Serrano C showing no internal hyphae formation. No

Table 1
Effects of different mycorrhizal species [*Glomus intraradices* (*Gi*) and *Gigaspora margarita* (*Gm*)] on the dry weights of shoot (SDW), root (RDW), and total (TDW) plants in various pepper genotypes

Pepper genotypes	SDW (g)			RDW (g)			TDW (g)		
	Gm	*Gi*	Control	*Gm*	*Gi*	Control	*Gm*	*Gi*	Control
Karaisali	0.205 b	0.325 a	0.365 a*	0.040 b	0.089 a	0.083 a**	0.245 b	0.413 a	0.448 a**
N52	0.328 a	0.265 a	0.120 b**	0.092 a	0.073 a	0.029 b*	0.420 a	0.338 a	0.150 b**
Hatay I.S.	0.345 a	0.310 a	0.310 a	0.076 a	0.087 a	0.074 a	0.421 a	0.396 a	0.375 a
Alata 42	0.248 a	0.356 a	0.359 a	0.049 b	0.081 a	0.089 a*	0.297 a	0.445 a	0.439 a
Demre	0.363 a	0.218 b	0.236 b**	0.089 a	0.041 b	0.052 b**	0.453 a	0.259 b	0.288 b**
Kandil	0.309 a	0.329 a	0.273 a	0.084 a	0.108 a	0.082 a	0.394 a	0.436 a	0.356 a
Serrano C.	0.232 a	0.294 a	0.239 a	0.071 a	0.097 a	0.059 a	0.303 a	0.391 a	0.298 a
Cayenne L.S.	0.302 a	0.295 a	0.354 a	0.112 a	0.075 a	0.113 a	0.414 a	0.371 a	0.467 a

For each parameter, values within a row not followed by the same letter are statistically different (**$P < 0.01$, *$P < 0.05$, respectively).