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Full Length Research Paper

Effect of arbuscular mycorrhizal (AM) inoculation on growth of Chili plant in organic manure amended soil

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Arbuscular mycorrhizal (AM) fungi are well known for their plant growth promoting efficiency and providing bio-protection against soil–borne pathogens (bacterial, fungal and parasitic nematodes). The efficiency of AM fungi as bio-control agents in commercial organic agriculture is gaining significance in recent decades. However, little information is available regarding beneficial role of AM symbiosis in organic manure amended soil. In the present work, an attempt has been made to study the growth performance of Chili (*Capsicum frutescens* L.) inoculated with AM fungi in soil amended with different dosages of organic manure. The experiment was conducted in a randomized design with four levels of organic manure (0, 50, 100 and 150%) and inoculation with five different AM Fungi species (*Acaulospora denticulata*, *Gigaspora albida*, *Glomus geosporum*, *Scutellospora corolloidea* and *Scutellospora scutata*). Plants were harvested after 3 months from the date of planting and plant growth was recorded. The inoculation with AM fungi at different levels of organic manure showed significantly more shoot and root dry weight than the non-mycorrhizal plants. The nitrogen content in shoot showed mixed response, resulting into significantly more nitrogen in *G. geosporum*, *S. corolloidea* and *S. scutata* inoculated plants in comparison to the non-mycorrhizal plants as well as plants inoculated with *A. denticulata and G. albida*. The Phosphorus content in the shoot was highest at 150% of organic manure application with AM plants recording significantly more phosphorus content than the non-mycorrhizal plants. Percent root infection by all AM fungi increased significantly due to amendment of soil with organic manure. Maximum root infection was caused at 100% of organic manure application in soil.

Key words: Arbuscular mycorrhizal fungi, organic manure, symbiosis, bio-control agents, *C. frutescens* L.

INTRODUCTION

Agricultural practices such as use of fertilizers and biocides, tillage, monocultures and growing of non-mycorrhizal crops are detrimental to AM, leading to impoverished agro-ecosystems that may not provide the full range of benefits to the crops. Organic farming systems may be less detrimental to AM because they exclude the use of water-soluble fertilizers and most biocides generally have diverse rotations. AM might therefore be able to substitute for reduced fertilizer and biocide inputs in organic systems, though there is little evidence for increased yield resulting from high rates of AM colonization in organic systems.

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Organic matter influences nutrient profile, soil structure, water holding capacity and pH, all of which directly and or indirectly influence AM development (Bagyaraj, 1991). Addition of organic amendment to soil has been reported to enhance plant biomass, mycorrhizal infectivity, proliferation of AM fungal hyphae in soil (St. John et al., 1983; Joner and Jacobsen, 1995) and spore density of action message format (AMF) (Noyd et al., 1996). It has been suggested that mycorrhizal plants at early growth stage utilize a substantially higher amount of P released from organic matter than non-mycorrhizal plants. Jayachandran et al. (1992) and Joner and Jacobsen (1994) have reported utilization of organic P by AM fungi and its transport to the plant. Tarafdar and Marschner (1994) observed a stimulatory effect of organic P in the form of phytate on mycorrhizal infection and hyphal growth as well as the efficient use of phytate-P by

phosphatase of mycorrhizal hyphae. They observed that mycorrhizal contribution accounted for 24 to 33% of the total P uptake with P supplied in inorganic form as Ca $(H_2PO_4)_2$ and 48 to 59% with P supplied in organic form as Na-phytate. Increased activity of acid phosphatase has been found in the roots (Gianinazzi et al., 1979; Thiagarajan and Ahmad, 1994) and in the rhizosphere (Dodd et al., 1987; Tarafdar and Marschner, 1994) of plants colonized by mycorrhizal fungi and this increased phosphatase activity in mycorrhizal roots and fungal hyphae has been suggested as a potential mechanism for mycorrhizal utilization of organic P (Joner et al., 2000).

It has been also suggested that mycorrhizal plants can derive nitrogen from organic sources that are less available to non-mycorrhizal plants (Ames et al., 1984; Barea et al., 1987, 1989; Ibijbijen et al., 1996). AM fungi have been reported to proliferate in organic matter and scavenge the mineral N released from soil organic particles (St. John et al., 1983; Hamel, 2004). The hyphae of AM fungi can also take up amino acids (Hawkins et al., 2000; Govindarajulu et al., 2005). Based on the observation of hyphae and vesicles of AM fungi in decomposing leaves of *Myrica parvifolia*, *Myrica pubescens*, and *Paepalanthus* sp., (Aristizábal et al., 2004) proposed that AM fungi enter decomposing leaves through vascular tissues and efficiently recycle the mineral nutrients released by microbial decomposers. The ability of AM fungi to use dead organic substrates (Talbot et al., 2008) is a matter of debate, but even if this ability is small or nonexistent, these fungi may be important in N cycling through their influence on the free-living soil microbial community (Andrade et al., 1997; Marschner et al., 2001; Hodge, 2003a, b; Aneja et al., 2006), which is responsible for most of the N mineralization, particularly in grassland ecosystems (Stanton, 1988).

Despite the key role of organic matter in soil ecosystems (Lejon et al., 2007), limited information on the effect of soil organic matter on AM fungi is available. Organic amendment with narrow C: N ratio has been found to have a greater influence on AMF proliferation compared with amendment with a wider C: N ratio (Graoker and Sreenivasa, 1994). In general, composted organic amendments (FYM, chicken litter, leaf compost, cow manure, biogas spent slurry) have a positive influence on the proliferation of mycorrhizal mycelium in soil (Gaonker and Sreenivasa, 1994; Douds et al., 1997). Soil organic amendments has been found to both increase (Hepper and Warner, 1983; St. John et al., 1983; Joner and Jakobsen, 1990; Rydlová and Vosátka, 2000; Gryndler et al., 2002; Albertsen et al., 2006; Gryndler et al., 2006) decrease (Avio and Giovannetti, 1988; Calvet et al., 1992; Ravnskov et al., 1999; Ravnskov et al., 2006) the growth of AM fungi. High amount of soil organic matter has been found to be associated with decreased mycorrhizal colonization as well as both root and shoot dry weight of the host plant as a result of increased concentration Mn that might be toxic for AM symbiosis (Aziz and Habte, 1988). Soils from plots managed by low input farming system for last 15 years had been found to have an enhanced capacity to initiate AM symbiosis (Mäder et al., 2000a). Ryan et al. (1994) have found 2 to 3 times higher colonization levels in wheat grown on organic farm than on conventional high input farm. Giovanetti and Avio (1985) found that additions of different materials, which increased the pore volume in soil, had a beneficial effect on mycorrhizal growth response, colonization and spore numbers. Douds et al. (1997); Harinikumar and Bagyaraj (1989) have reported increased sporulation of some AMF species and propagules density in the soil due to organic fertilization. Increased number of AM propagules in soil has been correlated with improved plant P uptake (Harinikumar et al., 1990). Douds et al. (1997) found that an enhanced spore populations of *Glomus etunicatum* group and the general *Glomus* sp. group including *G. mosseae* in dairy cow manure/leaf compost and chicken litter/leaf compost treated plots in comparison to those found in plots treated with conventional fertilizer and raw cow manure.

AM fungal inoculants are now widely used in India to the satisfaction of increasing numbers of organic gardeners and farmers. Organic farming severely restricts the use of artificial chemical fertilizers and pesticides. Instead, it relies on developing a healthy, fertile soil and growing a mixture of crops. Supplementing the nutrient requirement of crops through organic composts and manures is essential for sustaining soil fertility and crop production.

There is a growing interest in the *Capsicum annuum*-AM symbiosis related to plant phosphorus, water uptake, and growth, plant nutritional status, gas exchange characteristics and yield (Bagyaraj and Sreeramulu, 1982; Davies and Linderman, 1991; Davies et al., 1993). Preinoculation with AM improves growth and yield of Chili transplanted in the field and save phosphatic fertilizers (Bagyaraj and Sreeramula, 1982). However, little is known about the role of AM fungi in improving growth of Chili plants. Moreover, no studies in Arunachal Pradesh regarding the use of AM biofertilizers as alternatives to chemical fertilizers have been undertaken for this crop plant. Chili is an economically important crop of the state mostly cultivated on a small scale. Hence, in the proposed work, an attempt has been made to select efficient AM fungi as well as optimum levels of P, N and organic matter for better growth of Chili. AM fungi have been reported to lessen transplantation shock thereby reducing seedling mortality. An attempt has been made to analyze the effect of AM inoculation and amendment of organic manure on the growth performance of Chili.

MATERIALS AND METHODS

Soil samples for pot experiments were collected up to a soil depth

of 10 to 15 cm in sterilized polythene bags from Botanic garden of Rajiv Gandhi University. The texture (Hydrometer analysis), bulk density (Blacke and Hartage, 1986), water holding capacity, pH (pH meter), conductivity (Jackson, 1958), organic carbon (Walklely and Black, 1934), total nitrogen (Microkjeldhal method), available P (Digestion method) and available K (Centrifugation and decantation method) of soil were obtained by applying aforesaid methods and instruments.

Dry weight of shoot was measured after oven drying at 80° C for 48 h. After the completion of data recording, the dried shoot parts were kept in paper bag covered with aluminium foil and stored for nitrogen and phosphorus estimation in shoot which was done by following the same method as described for the soil nutrient analysis. 50 mg of oven dried properly ground plant sample were used for this purpose. The plants grown in a green house under controlled environment conditions received approximately 30 to 35ºC day and 25ºC night temperatures and 12 h fluorescent illumination with 8000 lux light intensity. Plants were irrigated manually with distilled water according to the field capacity. Spores were isolated by wet-sieving and decanting method (Gerdemann and Nicolson, 1963; Daniels and Skipper, 1982).

Roots were washed carefully in tap water and placed in a test tube containing 2.5% KOH solution (w/v). Roots were then heated at 90°C in a water bath for 30 min (Koske and Gemma, 1989). Cooled root samples were washed several times with tap water and were acidified in 1% HCl solution for 30 min and stained in an acidic glycerol solution (500 ml H_2O, 50 ml 1% HCL) containing 0.05% tryphan blue (Phillips and Hayman, 1970).

The experiment was designed in a two-way factorial combination of four levels of organic manure (0, 50, 100 and 150% OM) in the soil and five AM fungal inoculation. Each treatment had five surviving replicates. Uninoculated plants at zero OM addition to the soil were termed as absolute control whereas inoculated plants at the same OM dose was termed as inoculated relative control. Uninoculated plants at other dosages of OM addition were termed as uninoculated relative control (URC). The recommended dosage of organic manure for Chili is 10 to 15 tons ha^{-1}. Organic manure in the form of vermicompost were obtained from Women Technology Park, Rajiv Gandhi University and was applied after sterilization by autoclaving @ 50, 100 and 150% of the recommended dose of organic manure at the time of sowing. NPK content of the vermicompost was 2.0, 1.1 and 1.9%, respectively.

Collected data were analyzed by one or two ways analysis of variance (ANOVA) using Microsoft excel. The values for percent infection in roots by AM fungi were Arcsin transformed.

RESULTS

Physico-chemical properties of the experimental soil

The physico-chemical analyses of soil samples reveals that soil texture of the experimental site was sandy loam with an average of 80.77% sand, 4.85% silt and 14.45% clay. The soil was slightly acidic with pH 5.8. The soil was deficient in available P (3.88 µg g^{-1}) and the organic carbon content was 1.54%.

Effect of different AM fungi and organic manure level in soil on growth of Chili plant

There was a significant effect on SDW of AMF inoculation and addition of organic matter in the soil ($P < 0.01$). SDW of both control and mycorrhizal plants increased with addition of more OM in the soil (Table 1 and Figure1). In general, inoculated plants produced significantly more SDW when compared to uninoculated relative control. On the basis of performance of plants, 100% OM application was found to be the best dose for the growth of both mycorrhizal and non-mycorrhizal plants. Further addition of OM resulted in a consequent decrease in SDW both in control and inoculated plants except *Glomus geosporum* and *Gigaspora albida* inoculated plants.

The inoculated plants at zero OM dose showed significantly more SDW than uninoculated control plants excepting *Scutellospora scutata*. A maximum increase at this dose was found due to inoculation with *G. geosporum* (2.48 g) followed by *Scutellospora coralloidea* (2.46 g) and a minimum in *Acaulospora denticulata* (2.30 g). *S. coralloidea* and *G. geosporum*, which were equally better than rest three AM species ($P < 0.05$) that did not show any significant difference among themselves.

At 50% OM application, inoculants performing statistically similar were *S. scutata*, *S. coralloidea*, *G. albida* and *G. geosporum.* The maximum SDW was recorded for *G. albida* (3.02 g) and least for *A. denticulata* (2.83 g).

At 100% OM fertilization, all AMF inoculated plants performed better than uninoculated plants (Table 1), the *S. coralloidea* inoculated plant being the best (3.11 g). Plants inoculated with other species attained almost equal SDW ($P > 0.05$).

Although there was a slight decrease in SDW at 150% of OM application in comparison to 100%, the yield was much higher than the uninoculated control plants at zero OM dose. At this level, the trend observed was similar as at zero OM application. The maximum and the minimum SDW was shown by *G. albida* (3.00 g) and *A. denticulata* (2.77 g) inoculated plants, respectively. The plant growth promoting efficiency of *G. albida* and *S. coralloidea* was equal ($P > 0.05$). Remaining species also showed no significant difference when compared among themselves.

The root dry weight significantly increased due to inoculation of five different AMF species and amendment of OM in the soil ($P < 0.01$). There was a significant effect of different OM dosages on root growth (Table 1 and Figure 2). An increasing trend in RDW from 50 to 100% and slight decrease at 150% OM amendment was observed. Although there was a decrease in RDW at 150% OM amendment, it was significantly more than that at zero OM amendment.

At zero amendment of OM, the maximum RDW was observed both in *S. coralloidea* and *G. geosporum* inoculated plants whereas the minimum in *S. scutata* inoculated plants. The amendment of 50% OM in soil along with AMF inoculation increased the production of RDW significantly. The RDW production was almost equal due to inoculation with *G. geosporum*, *S. coralloidea* or *G. albida*.

The application of OM at 100% dose also significantly increased RDW of inoculated plants than the relative control plants. A significant difference was recorded

Table 1. Effect of inoculation to *C. frutescens* L. with different AMF species on shoot length (SL), fresh weight (SFW) and dry weight (SDW) at different levels of OM fertilization (Means with same letter in row and number in column are not significantly different at P < 0.05).

	Arbuscular mycorrhizal fungi						
	OM levels	**Control**	***A. denticulate***	***G. albida***	***G. geosporum***	***S. coralloidea***	***S. scutata***
SDW (g)	0	2.12 ± 0.103^{a1}	2.30 ± 0.061^{b1}	2.31 ± 0.077^{b1}	2.48 ± 0.026^{c1}	2.46 ± 0.067^{c1}	2.24 ± 0.080^{ab1}
	50	2.44 ± 0.067^{a2}	2.83 ± 0.079^{b3}	3.02 ± 0.173^{c2}	2.90 ± 0.086^{bc2}	2.98 ± 0.108^{bc2}	2.96 ± 0.044^{bc23}
	100	2.68 ± 0.179^{a3}	2.97 ± 0.067^{bc4}	3.04 ± 0.150^{bc2}	2.91 ± 0.080^{b2}	3.11 ± 0.106^{c3}	3.00 ± 0.157^{bc3}
	150	2.39 ± 0.080^{a2}	2.77 ± 0.052^{b2}	3.00 ± 0.162^{d2}	2.81 ± 0.054^{b2}	2.96 ± 0.087^{cd2}	2.85 ± 0.059^{bc2}
RDW (g)	0	0.25 ± 0.007^{a1}	0.33 ± 0.025^{b1}	0.34 ± 0.018^{b1}	0.35 ± 0.018^{b1}	0.34 ± 0.010^{b1}	0.32 ± 0.016^{b1}
	50	0.34 ± 0.010^{a2}	0.41 ± 0.024^{b23}	0.42 ± 0.015^{bc2}	0.44 ± 0.026^{c2}	0.42 ± 0.012^{bc2}	0.41 ± 0.015^{b3}
	100	0.36 ± 0.006^{a2}	0.42 ± 0.021^{b3}	0.43 ± 0.021^{bc2}	0.44 ± 0.021^{cd2}	0.45 ± 0.016^{d3}	0.43 ± 0.021^{bc4}
	150	0.35 ± 0.018^{a2}	0.40 ± 0.009^{bc2}	0.42 ± 0.023^{cd2}	0.42 ± 0.019^{d2}	0.41 ± 0.015^{cd2}	0.38 ± 0.008^{b2}

LSD (%)		**SDW**	**RDW**
AMF	5	0.141	0.024
	1	0.187	0.032
OM Levels	5	0.115	0.020
	1	0.152	0.026

between *S. coralloidea* and *G. geosporum* with *A. denticulata* and *S. coralloidea* with *G. albida* (P < 0.05). Although there was a decrease in RDW at 150% OM amendment in all AMF inoculated plants in comparison to 100% dose, the quantity was more than in inoculated plants at zero OM application. At this dose of OM application, there was no significant difference in root fresh weight between *S. coralloidea*, *G. albida*, *G. geosporum* and *A. denticulata* (P > 0.05). Similarly *S. coralloidea*, *G. albida* and *G. geosporum* inoculated plants produced similar RDW but significantly more than *S. scutata* inoculated plants (P < 0.05).

Increasing trend of N content in shoot was observed with application of OM dosage from 0 to 150%. There was a significant variation between AMF species in increasing N content. At zero OM application, both inoculated and uninoculated Chili plants had the minimum N content. Except, *A. denticulata* and *G. albida*, rest of the three inoculants significantly improved N content than that present in uninoculated control plants (P < 0.01). At 50% OM application, except *A. denticulata* and *G. albida*, other three inoculants significantly increased N content over the respective uninoculated control plants, *G. geosporum* being the best inoculant followed by *S. coralloidea* and *S. scutata*. Again at 100 and 150% OM dose, *G. geosporum* and *S. coralloidea* were the best two inoculants. *S. scutata* also enhanced N content significantly higher than the remaining two AMF. Plants inoculated with the later species showed N content either equal or less than the respective uninoculated control.

Application of organic manure as well as AMF inoculation significantly affected the P content in shoot (Table 2). The P content increased with the application of OM dosage from 0 to 150% and there was a significant variation in the P uptake efficiency of different AMF species as well. Uninoculated Chili plants had the minimum P content at all applied dosage of OM. *G. geosporum* and *S. coralloidea* enhanced P content more than any other AMF at all dosage of OM. Moreover, no significant variation between these two species was found except at 50 and 100% dosages of OM. *S. scutata* was the next species giving a better P status to the plants at all OM dosages. P uptake efficiency was significantly higher than *G. albida*. *A. denticulata* could enhance P content in

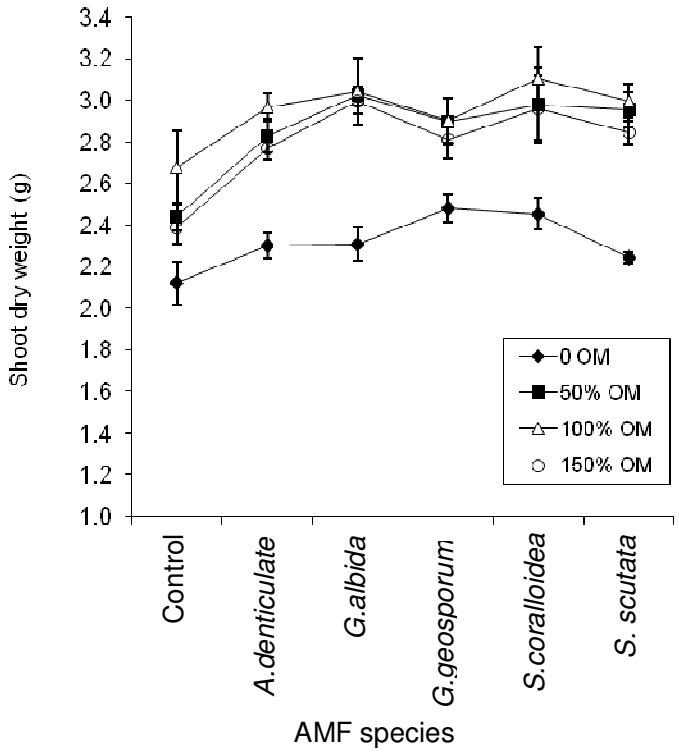

Figure 1. Shoot dry weight of Chili at different levels of OM amendment.

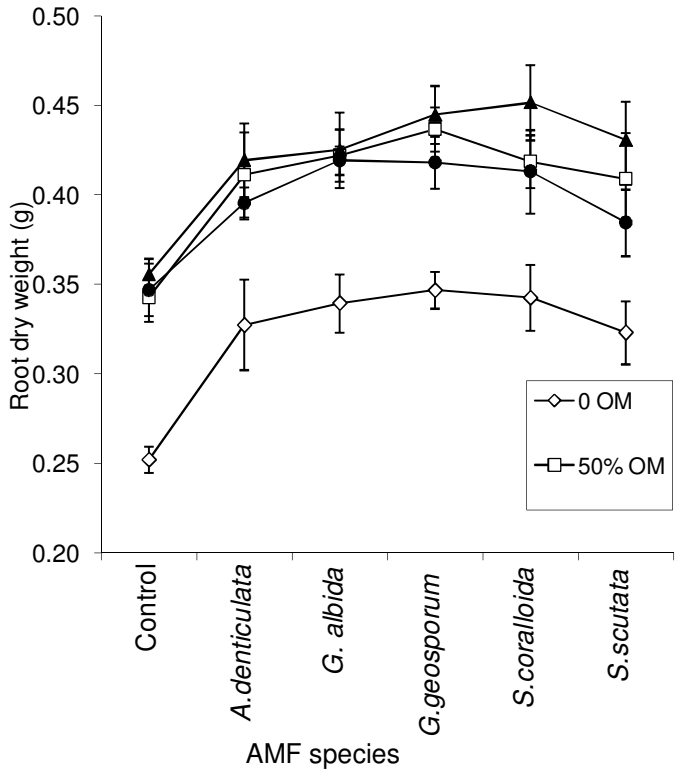

Figure 2. Root dry weight of Chili at different levels of OM amendment.

shoot better than *G. albida* only at 50 and 100% OM level. The P content of *G. geosporum*, *G. albida*, *S. scutata* inoculated and uninoculated control Chili plants increased successively with increase in OM dosage from 0 to 150% significantly whereas in case of *A. denticulata* and *S. coralloidea* inoculated plants the successive increase could be found only up to 100% OM application.

Effect of organic matter content in soil on AM fungi

Percent root infection by all AMF increased significantly due to amendment of soil with organic manure ($P < 0.05$). There was a significant variation in the percent root infection caused by different AMF species also ($P < 0.01$). However, there was no interaction between OM amendment and AMF species. At zero application of OM in the soil, *G. geosporum* showed highest percent root infection (39.74%), significantly more than other AMF species except *S. coralloidea* (Table 3 and Figure 3). Percent root infection caused by *A. denticulata*, *S. scutata* and *G. albida* was found be the equivalent.

At 50% OM application, significantly highest percent root infection ($P < 0.05$) was caused by *G. albida* (42.70%). There was no significant difference in the infectivity of *G. geosporum* (39.17%), *A. denticulata* (38.58 %) and *S. coralloidea* (37.23%). *S. scutata* showed the minimum root infection (31.85%). When OM amendment was done @ 100%, the percent root infection caused by *A. denticulata* (42.07%), *G. geosporum* (42.06%) and *G. albida* (41.49%) was statistically similar. *S. coralloidea* (38.02%) and *S. scutata* (34.96%) caused significantly less infection than the above mentioned species ($P < 0.05$). At 150% OM dose, the percent root infection was significantly higher in case of *G. albida*, *G. geosporum* and *S. coralloidea* than *A. denticulata* and *S. scutata* ($P < 0.05$). There was no significant difference among the later two species.

The percent root infection by *G. geosporum* and *S. coralloidea* did not increase due to addition of OM in the soil whereas it increased significantly in the case of *A. denticulata* with successive addition of OM up to 100%. Other two inoculants showed slightly different trend. The infection remained constant in case of *S. scutata* whereas in case of *G. albida* it increased significantly at 50% dose and thereafter became constant.

DISCUSSION

Application of organic manure changes the availability of plant nutrients by affecting both physical (like increased soil porosity, water holding capacity and reduced mechanical resistance) and biological characteristics of the soil. In the present study, both AM treatments and organic manure application significantly increased both above and below ground biomass of plants as well as the nutrient contents. However, the response of all inoculants

Table 2. Effect of inoculation to *C. frutescens* L. with different AMF species on shoot N and P contents and MEI (%) at different levels of OM fertilization (Means with same letter in row and number in column are not significantly different at P < 0.05).

		Arbuscular mycorrhizal fungi					
	OM Levels	**Control**	***A. denticulata***	***G. albida***	***G. geosporum***	***S. coralloidea***	***S. scutata***
%N	0	F	2.7 ± 0.084^{ab1}	2.8 ± 0.032^{b12}	3.2 ± 0.032^{d1}	3.2 ± 0.032^{d1}	3.0 ± 0.032^{c1}
	50	2.8 ± 0.045^{a2}	2.8 ± 0.130^{a12}	2.7 ± 0.100^{a1}	3.5 ± 0.161^{d2}	3.3 ± 0.077^{c12}	3.1 ± 0.063^{b12}
	100	3.0 ± 0.114^{b3}	2.9 ± 0.071^{ab23}	2.8 ± 0.071^{a12}	3.6 ± 0.105^{e23}	3.4 ± 0.158^{d23}	3.2 ± 0.089^{c23}
	150	3.0 ± 0.055^{a3}	3.0 ± 0.084^{a3}	2.9 ± 0.084^{a2}	3.7 ± 0.167^{d3}	3.5 ± 0.224^{c3}	3.3 ± 0.158^{b3}
%P	0	0.15 ± 0.010^{a1}	0.16 ± 0.007^{b1}	0.17 ± 0.007^{c1}	0.19 ± 0.007^{e1}	0.18 ± 0.007^{d1}	0.17 ± 0.007^{c1}
	50	0.25 ± 0.002^{a2}	0.27 ± 0.001^{c2}	0.26 ± 0.004^{b2}	0.28 ± 0.001^{d2}	0.28 ± 0.003^{d2}	0.27 ± 0.002^{c2}
	100	0.28 ± 0.008^{a3}	0.30 ± 0.006^{c3}	0.29 ± 0.003^{b3}	0.32 ± 0.013^{d3}	0.32 ± 0.013^{d3}	0.30 ± 0.004^{c3}
	150	0.29 ± 0.003^{a4}	0.30 ± 0.004^{b3}	0.30 ± 0.004^{b4}	0.33 ± 0.001^{e4}	0.32 ± 0.013^{d3}	0.31 ± 0.005^{c4}

	LSD (%)	**%N**	**%P**
AMF	5	0.147	0.009
	1	0.194	0.012
OM Levels	5	0.120	0.008
	1	0.159	0.010

Table 3. Percent root infection in *C. frutescens* L. by AM fungi at different levels of OM in the soil (Means with same letter in row and number in column are not significantly different at P < 0.05).

	Pencentage root infection*			
	OM levels			
AM Fungi	**0**	**50**	**100**	**150**
A. denticulata	33.13 ± 1.3^{a1}	38.58 ± 2.1^{b2}	42.07 ± 5.7^{c2}	32.41 ± 2.4^{a1}
G. albida	34.91 ± 2.7^{a12}	42.70 ± 3.9^{b3}	41.49 ± 2.8^{b2}	39.78 ± 1.3^{b2}
G. geosporum	39.74 ± 2.8^{a3}	39.17 ± 1.9^{a2}	42.06 ± 6.5^{a2}	39.74 ± 2.8^{a2}
S. coralloidea	36.84 ± 0.6^{a23}	37.23 ± 4.9^{a2}	38.02 ± 1.0^{a1}	38.53 ± 3.0^{a2}
S. scutata	32.46 ± 1.6^{ab1}	31.85 ± 1.2^{a1}	34.96 ± 1.9^{b1}	33.64 ± 3.2^{ab1}

	AMF		**OM levels**	
LSD (%)	5	1	5	1
	3.430	4.533	3.068	4.054

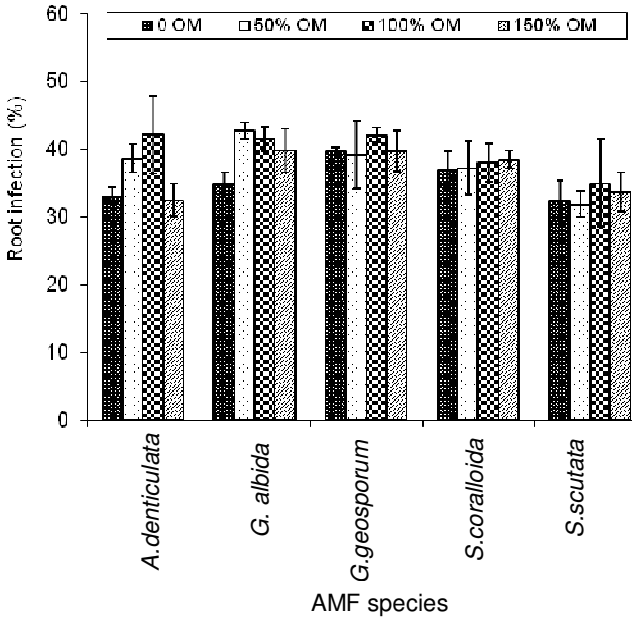

Figure 3. Percent root infection in Chili at different levels of OM amendment.

varied greatly at different doses of OM. The maximum SDW at 100% OM dose was recorded in plants inoculated with *S. Coralloidea,* followed by *G. albida*, *S.scutata* and *A. denticulata* whereas at 50% OM dose it was *G. albida*, *S. coralloidea*, *S. scutata* and *G. geosporum* respectively. There was no OM dose effect on the efficiency of *G. albida*, *S. scutata* and *G. geosporum* after 50% OM level. SDW of Chili was at its minimum in all the treatments when no manure was applied to the soil. This might be due to poor nutrient status of the experimental soil. Similar result has been reported by Gryndler et al. (2002) that relatively low amounts of organic matter in the soil can affect both plant growth in terms of shoot dry weight or root length.

Results of the present experiment showing improvement in growth of inoculated Chili with addition of OM to the soil is in agreement with the findings of George (2000) and Neumann and George (2005) that AMF plays a vital role in better growth to their host as these fungi are capable to assist the plant in the uptake of essential nutrients such as P, N, Zn, Cu, and sometimes K. Amendment with organic matter not only improves soil fertility but also stimulates development of AM fungi in soil (Calvet et al., 1992; Joner and Jakobsen, 1992; Rydlová and Vosátka, 2000; Albertsen et al., 2006; Gryndler et al., 2006; Ravnskov et al., 2006) and roots (Branzanti et al., 1992; Groaker and Sreenivasa, 1994). The maximum increase in root fresh and dry weight was due to *G. geosporum*, *G. albida* and *S. coralloidea* at all dosages of OM.

Percent root infection by all AMF increased significantly due to amendment of soil with organic manure and the highest infection was observed at 100% OM application for all AMF except *S. scutata*. Further addition @ 150% OM decreased percent root infection. *S. coralloidea* and *G. geosporum* produced maximum RI at 100% OM whereas *S. coralloidea, S. scutata* and *G. geosporum* were the most infective species at 50% OM. *A. denticulata* and *G. albida* always produced equal infection. Groaker and Sreenivasa (1994) also reported enhancement of root colonization in wheat as a result of organic amendment. Giovanetti and Avio (1985) found that additions of different materials that increase the pore volume in soil had a beneficial effect on AM colonization and spore numbers.

Increasing the rate of OM and inoculation with AMF species increased shoot nutrient concentrations. Enhanced shoot P significantly over control plants due to both AM application and organic manure application has been also observed by Verma and Arya (1998). Perner et al. (2007) also observed similar increase in nutrient content in *Pelargonium* plants due to AMF and levels of compost supply. This may be due to influence of AMF over their host plants in uptake of essential nutrients from organic manure that contains more than 30 different organic P compounds (Barrow, 1961; Dalal, 1977) which are easily degraded in soil and become available to plants (Martin, 1973). The higher shoot NP contents found in AM plantlets is probably due to more efficient uptake of available P from the soil and manure and possibly to mineralization of organic phosphorus (Jayachandran et al., 1992) due to a higher phosphatase production by AM plants (Tarafdar and Marschner, 1994). A greater phosphate absorption by AM fungi has been suggested to have arisen due to superior efficiency of uptake from labile forms of soil phosphate and under certain conditions AMF is known to absorb fixed phosphate and even to stimulate root phytase activities (Pearson and Gianinazzi, 1983). Saprophytic growth of mycorrhizal fungi in the soil (Hepper and Warner, 1983) and presence of mycorrhizal mycelium in the decomposing organic material (Nicolson and Johnson, 1979) has also been observed, and the preferential association of AM hyphae with organic-rich microsites has been attributed for better utilization of organic matter by AM plants (St. John et al., 1983).

Conclusion

There was a significant effect of different level of organic OM and inoculation of AMF on shoot and root dry weight nutrient contents and %RI in Chili plants. Application of 100% OM was found to be the best dose for the growth of both AM and NM plants. Maximum SDW at 100% OM dose was recorded in plants inoculated with *S. coralloidea* followed by *G. albida*, *S. scutata*, *A. denticulata* and *G. geosporum*. However, AM plants with *S. scutata*, *G. albida* or *G. geosporum* showed a non significant increase in SDW over 50% OM dose. Nevertheless, AM plants had always significantly more

SDW than NM relative control. A significant effect of different OM dosages on root growth was found in both AM and NM plants. RDW increased at 100% OM when compared to 50% OM. It decreased slightly at 150% OM amendment, but still significantly more than that at zero OM amendment. RDW was more in *S. coralloidea*, *G. geosporum* and *G. albida* inoculated plants. Both N and P contents in shoot increased with OM dosage from 0 to 150%. There was a significant variation in the efficiency of AMF species with *G. geosporum* and *S. coralloidea* always bestowing the highest uptake. Amendment with OM significantly increased %RI by all inoculants. Root infection increased with addition of OM and the highest level was observed at 100% application for all AMF except *S. scutata*. Further addition @ 150% OM decreased the %RI. *S. coralloidea* and *G. geosporum* produced maximum %RI at 100% whereas at 50% OM *S. coralloidea, S. scutata* and *G. geosporum* were the most infective species. *A. denticulata* and *G. albida* always produced equal infection.

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