Indian Journal of Agricultural Sciences **83** (11): 1265–8, November 2013/Short Communication

Beneficial response of *Glomus* species on chilli (*Capsicum annuum*)

POONAM JOSHI[1] , R K KAUL[2] and J C TARAFDAR[3]

Central Arid Zone Research institute, Jodhpur, Rajasthan 342 003

Received: 1 September 2011; Revised accepted: 1 May 2013

Key words: Chilli, *Glomus fasciculatum, G. mosseae,* Susceptibility

Arbuscular mycorrhizal fungi benefit plants by way of providing nutrition, stress resistance and improvement in soil structure (Barea and Jeffries 1995, Barea *et al.* 2002, Qiang-Sheng Wu *et al*. 2008, Medina and Azcon 2010). They are known to promote growth of plants by converting non-available form of phosphorus into available form (Tarafdar and Marschner 1994). The soils of arid western Rajasthan are known to support many species belonging to different genera of AM fungi (Verma *et al*. 2008, Pande and Tarafdar 2004). Amongst them *Glomus* species are of common occurrence. The species of this genus are known to form associations with trees, medicinal and horticultural plants (Bala *et al*. 1989, Panwar and Tarafdar 2006). Chilli (*Capscicum annuum*) an important cash crop of India is widely cultivated in western part of Rajasthan state. Many species of AM fungi are reported to form association with this crop (Nam-Seok 2006, Castillo *et al*. 2010, Kim *et al.* 2011, Claudia Castillo *et al*. 2009). Sreenivasa (1992) reported local isolate of *Glomus macrocarpum* to be the best in improving the growth of chilli as well as uptake of P, Zn, Cu, Mn and Fe. Our surveys of the crop in the Jodhpur district of Rajasthan revealed existence of few species of AM fungi in the rhizosphere soil and roots of the plants. In most of the samples two species of *Glomus,* i.e. *G. fasciculatum* and *G. mosseae* were encountered (unpublished). The plants colonized by the species showed better growth and less of infection of root-knot nematode. Considering the beneficial effects of the AM fungi, an investigation was undertaken to study the comparative susceptibility of chilli to *G. fasciculatum* and *G. mosseae* for exploitation as growth promoting and disease controlling bio-agent.

The study was conducted in specially made earthen tubes of 100 cc soil capacity. Five tubes in each treatment (Control, *Glomus mosseae*, *Glomus fasciculatum*) were filled with 100 g of steam sterilized soil. Three seeds of chilli/ tube were sown and 10 days after germination, one seedling/tube was maintained. When the seedlings were 30 days old, the top soil was removed to expose the roots. The roots were inoculated with 100 spores/ 2ml water inoculum of *G. fasciculatum* or *G. mosseae*. After the inoculation, the roots were again covered with sterilized soil and lightly irrigated. One month after inoculation of plants, chilli seedlings were harvested for observations on growth and root colonization and density of infection. The root slide technique of Read *et al*. (1976) was adopted for determining the percent root infection after clearing and staining the roots by the method of Phillips and Hayman (1970). Observations were also recorded on rhizosphere soil enzyme activities, total chlorophyll and nitrate reductase activity in fresh leaves. The various soil enzymes estimated were dehydrogenase, acid and alkaline phosphatases, phytase and esterase. Dehydrogenase assay was measured in soils immediately after soil sampling. Dehydrogenase activity was assayed by the method of Tabatabai (1982). The acid and alkaline phosphatases were assayed by adopting the procedure of Tabatabai and Bremner (1969). Phytase activity was assayed by the method of Ames (1966). Esterase activity was determined by measuring the hydrolysis of fluorescein diacetate (FDA) (Schnuver and Rosswall 1982) and the green colour fluorescein diacetate was quantified by spectrophotometry. The total chlorophyll in fresh leaves was estimated by following Arnon (1949) method. The nitrate reductase activity in fresh leaves was estimated by following Jaworski (1971) method. The inoculum of the AM for the experiment was derived from the pot cultures of the fungus multiplied on *Cenchrus ciliaris* plants raised in the sterilized soil. Viable AM-fungal spores in the rhizosphere soil were isolated by adopting the wet sieving and decanting technique employing sucrose gradient solution (Furlan and Fortin 1975). Analysis of variance data was carried out. The least significance difference was calculated (P = 0.05) using *t*-method (Sokal and Rohlt 1981).

[1]Senior Research Fellow (e mail: joshi_poonam82@yahoo.co.in), NAIP (Nanotechnology), [2]Principal Scientist (Nematology) (e mail: kaulrk303@gmail.com), Plant Improvement, Propagation & Pest Management Division, [3]ICAR National Fellow (e mail: jctarafdar@yahoo.in), National Fellow Unit

Table 1 Effect of two species of *Glomus* on seedling growth and root colonization of chilli

Treatment	Shoot weight (g)		Root weight (g)		%	Density of
	Fresh	Dry	Fresh	Dry	colonization	infection
Glomus mosseae	1.42	0.20	0.64	0.12	85.33 (68.61)*	60.44 (51.04)*
Glomus fasciculatum	1.80	0.27	0.99	0.18	89.50 (71.36)	78.79 (62.79)
Absolute check	0.80	0.14	0.24	0.08	0.00	0.00
LSD (P = 0.05)	0.28	0.06	0.15	0.07	16.82	12.18

*Figure in parenthesis are arc-sine transformed values

Chilli seedlings were observed susceptible to both the species of *Glomus,* i.e. *G. fasciculatum* and *G. mosseae*. Both species caused increase in the fresh and dry weights of shoot and root over the check. *G. fasciculatum* treatment caused maximum improvement in the weights and it was significantly higher than that of the check and *G. mosseae* treatment except for dry weight of root where it was at par with that of the *G. mosseae* treatment (Table 1). Though *G. mosseae* was observed to increase shoot/root weights but the increase in dry weights in this treatment did not differ significantly from that of the check treatment. In general *G. fasciculatum* proved superior to *G. mosseae* in increasing fresh and dry weights of shoot and root. Observations on percent colonization of roots revealed both the species to be at par with each other though *G. fasciculatum* showed slightly higher percent colonization as compared to *G. mosseae*. The density of infection of roots in *G. fasciculatum* inoculated plants was observed significantly higher than that of *G. mosseae* colonized plants.

Observations on rhizosphere enzymes (Table 2) revealed significant improvement in the activities of acid and alkaline phosphatase in AM colonized plants as compared to the check. Inoculation of *G. fasciculatum* was observed to cause significantly higher secretion of phosphatases than *G. mosseae*. The percent increase in the acid and alkaline phosphatase activities was 46.9 and 65.9% in *G. fasciculatum* as compared to 34.6 and 53.4% in *G. mosseae* rhizosphere soil over the check treatment. Both the species of *Glomus* also showed increased activities of phytase and dehydrogenase enzymes. Phytase activity was observed to increase by 45.4 and 36% and dehydrogenase activity increased by 45.6 and 45.2% over the check in *G. fasciculatum* and *G. mosseae* treatments respectively. The AM inoculation also enhanced the esterase activity and it was recorded maximum, i.e. 51.6% higher in *G. fasciculatum* and 27.1% higher in *G. mosseae* treatments over the check. There was a significant enhancement in the synthesis of total chlorophyll and nitrate reductase activity in the fresh leaves of chilli plants colonized by either of the *Glomus* species (Table 2). The total chlorophyll content increased by 29.6 and 23.2% and nitrate reductase activity improved by 43 and 35.6% over the check in *G. fasciculatum* and *G. mosseae* inoculated plants.

In general both species of *Glomus* colonized the roots of chilli and their association resulted in improvement in fresh and dry weights of shoot and root over the check treatment. Between the two species, *G. fasciculatum* proved superior as it caused significantly higher increase in fresh and dry weights of shoot and fresh weight of root over *G. mosseae*. The same was also true in case of the density of infection which was significantly higher in *G. fasciculatum* colonized plants. Though both the species were observed to cause significantly higher activities of various rhizosphere enzymes over the check but the enhancement in the activities was higher in *G. fasciculatum* treatment as compared to *G. mosseae*. The enhancement in acid phosphatase, alkaline phospahatase, dehydrogenase and esterase activites in *G. fasciculatum* treatment were 12.3, 12.5, 13.5 and 24.5% higher than that of *G. mosseae* treatment. Similar trend was also visible with respect to total chlorophyll content and nitrate reductase activity in fresh leaves and it was significantly higher in *G.*

Table 2 Effect of *Glomus* species on various rhizosphere soil enzyme activities and total chlorophyll content and nitrate reductase activity in the fresh leaves of chilli plants

Treatment	Acid phosphatase (EU × 10^{-5})	Alkaline phosphatase (EU × 10^{-5})	Phytase (EU × 10^{-3})	Dehydrogenase (p kat/g)	Esterase (EU × 10^{-3})	Total chlorophyll (mg/g^{1})	Nitrate reductase (μ mol/h)
G. mosseae	2.63	4.62	8.23	3.95	2.85	12.47	1.21
G.fasciculatum	3.24	6.31	9.64	4.92	4.29	13.60	1.36
Absolute check	1.72	2.15	5.27	2.69	2.08	9.57	0.78
LSD (P = 0.05)	0.20	0.16	0.37	0.20	0.18	0.78	0.08

fasciculatum treatment as compared to *G. mosseae* colonized plants. Many workers have reported susceptibility of solanaceous plants in general and chilli in particular to different species of AM fungus. Sreenivasa (1992) studied the response of chilli to two species of *Glomus* and one each of *Gigaspora margarita*, *Acaulospora laevis* and *Sclerocystis dussii*. They recorded *G. macrocarpum* to be the best in improving the growth of *C. annuum* over other species. They also compared *G. fasciculatum* and *G. macrocarpum* and observed *G. macrocarpum* to cause maximum increase in growth, yield and nutrient status of chilli as compared to *G. fasciculatum*. Sreenivasa *et al.* (1993) compared the response of 30 day old seedlings of chilli to the most efficient strain of *G. macrocarpum* and *G. fasciculatum* at different levels of phosphorus fertilization. They reported that *G. macrocarpum* caused maximum increase in growth, yield and nutrient status of plants at 50% of the recommended dose of P that was added in the soluble form. Sreeramulu and Bagyaraj (1986) tested three species of *Glomus,* viz. *G. fasciculatum*, *G. albudum* and *G. macrocarpum* and observed *G. fasciculatum* to cause maximum increase in growth and yield of chilli plants. Our studies indicate that under arid conditions, chilli is a preferred host for both the species of *Glomus*. However between the two, *G. fasciculatum* is preferred more as it showed higher percent colonization of root and density of infection, and caused higher growth of plants as compared to the other species. The superiority of *G. fasciculatum* over *G. mosseae* is further supported by the fact that the species induced higher rhizosphere enzyme activity in the soil and increased chlorophyll content and nitrate reductase activity in the leaves. The species can be exploited as a suitable bio inoculant for achieving higher yield of chilli under arid conditions.

SUMMARY

Chilli, *Capsicum annuum* (var. RCH 1) was tested for susceptible response to two species of *Glomus,* i.e. *Glomus fasciculatum* and *G. mosseae*. The experiment was conducted in specially made earthen tubes of 100 cc soil capacity. AM spores we inoculated to roots @ 1 spore/ g soil. Observations on various plant growth parameters and biochemical studies in soil and plants were undertaken 30 days after imposition of the treatments. In general, chilli was observed susceptible to both the species of *Glomus*. However, *Glomus fasciculatum* proved superior to *Glomus mosseae* in causing maximum increase in plant growth parameters as well as root colonization and density of infection. Both species also improved rhizosphere activity of enzymes in the soil (i.e. dehydrogenase, alkaline and acid phosphatases, esterase and phytase), total chlorophyll content and nitrate reductase activity in the leaves but the improvement was more pronounced in case of *G. fasciculatum*. The studies suggested that chilli is more preferred host for *Glomus fasciculatum*.

REFERENCES

Ames B N. 1966. Assay of inorganic phosphate, total phosphate and phosphatases. *Methods in Enzymology* **8**: 115–8.

Arnon D I. 1949. Copper enzymes in isolated chloroplast: polyphenol oxidase in *Beta vulgaris*. *Plant Physiology* **24**: 1–15.

Bala K, Rao A V and Tarafdar JC. 1989. Occurrence of VAM association in different plant species of the Indian desert. *Arid Soil Research and Rehabilitation* **3**: 391–6.

Barea J M and Jeffries P. 1995. Arbuscular mycorrhizas in sustainable soil plant systems. (*in*) *Mycorrhiza: Structure, Function, Molecular Biology and Biotechnology,* pp 521–59. A Varma and B Hock (Eds). Springer-verlag, Heidelberg.

Barea J M, Toro M, Orozco M O, Campos E and Azcon R. 2002. The application of isotopic (p32 and N15) dilution techniques to evaluate the interactive effect of phosphate–solubilizing rhizobacteria, mycorrhizal fungi and Rhizobium to improve the agronomic efficiency of rock phosphate for legume crops. *Nutrient Cycling in Agroecosystems* **63**: 35–42.

Castillo C, Rubio R Borie F and Sieverling E. 2010. Diversity of arbuscular mycorrhizal fungi in horticultural production systems of southern Chile. *Journal Soil Science and Plant Nutrition* **10(4)**: 407–13.

Claudia Castillo R, Leonardo Sotomayor S, Cesar Ortiz O, Gina Leonelli C, Fernando Borie B and Rosa Rubio H. 2009. Effect of arbuscular mycorrhizal fungi on an ecological crop of chili peppers (*Capsicum annuum* L.). *Chilean Journal of Agricultural Research* **69(1)**: 79–87.

Furlan V and Fortin J A. 1975. Formation of endomycorrhizae by *Endogone calospora* on *Allium cepa* under three temperature regimes. *Naturaliste Canadien* **100**: 467–78.

Jaworski E K. 1971. Nitrate reductase assay in intact plant tissues. *Biochemical and Biophysical Research Communications* **43**: 1 274–9.

Kim K Yim, Trivedi W, Madhaiyan P, Boruah M, Islam H P D, Lee M R, G and Sa T. 2011. Synergistic effects of inoculating arbuscular mycorrhizal fungi and *Methylobacterium oryzae* strains on growth and nutrient uptake of red pepper (*Capsicum annuum* L.). *Plant and Soil* **327(1-2)**: 429–40.

Medina A and Azcon R. 2010. Effectiveness of the application of Arbuscular Mycorrhizal Fungi and organic amendments to improve soil quality and plant performance under stress conditions. *Journal of Soil Science and Plant Nutrition* **10(3)**: 354–72.

Nam-Seok Cho, Dong-Hun Kim, An-Heum Eom, Jeong-WooLee, Tae-Ho Choi, Hee-Yeon Cho, Andrzej Leonowicz and Shoji Ohga. 2006. Identification of symbiotic arbuscular mycorrhizal fungi in korea by morphological and DNA squencing features of their Spores. *Journal of The Faculty of Agriculture, Kyushu University* **51(2)**: 201–10.

Pande M, and Tarafdar J C. 2004. Arbuscular mycorrhizal fungal diversity in neem-based agroforestry systems in Rajasthan. *Applied Soil Ecology* **26(3)**: 233–41.

Panwar J and Tarafdar J C. 2006. Distribution of three endangered medical plant species and their colonization with arbuscular mycorrhizal fungi. *Journal of Arid Environments* **65**: 337–50.

Phillips J M and Hayman D S. 1970. Improved procedures for clearing roots and staining parasitic and vesicular arbuscular mycorrhizal fungi for rapid assessment of infection. *Transactions of Mycological Society* **55**: 158–61.

Qiang- Sheng Wu, Ren-XueXia and Ying-Ning Zou. 2008. Improved soil structure and citrus growth after inoculation with three arbuscular mycorrhizal fungi under drought stress. *European Journal of Soil Biology* **44(1)**:122–8.

Read D J, Kouckeki N K and Hodgson J. 1976. Vesicular-arbuscular mycorrhizal in natural vegetation system. I. The occurrence of infection. *New Phytologist* **77**: 641–53.

Schnüver J and Rosswall T. 1982. Fluorescein di-acetate hydrolysis as a measure of total microbial activity in soil and litter. *Applied Environmental Microbiology* **43**: 1256–61.

Sokal R R and Rohlf F J. 1981. *Biometry – The Principles and Practice of Statistics in Biological Research,* 2nd edn. W H Freeman & Co., New York.

Sreenivasa M N, Krishnaraj P U, Gangadhara G A and Manjunathaiah H M. 1993. Response of chilli (*Capsicum annuum* L.) to inoculation of an efficient vesicular arbuscular mycorrhizal fungus. *Scientia Horticulturae* **53(1-2)**: 45–52.

Sreenivasa M N. 1992. Selection of an efficient vesicular arbuscular mycorrhizal fungus for chilli (*Capsicum annuum* L.). *Scientia Horticulturae* **50(1-2)**: 53–8.

Sreeramulu K R and Bagyaraj D J. 1986. Field response of chilli to VA mycorrhiza on black clayey soil. *Plant and Soil* **93(2)**: 299–302.

Tabatabai M A and Bremner J M. 1969. Use of p-nitrophenyl phosphate for assay of soil phosphatase activity. *Soil Biology and Biochemistry* **1**: 301–7.

Tabatabai M A. 1982. Soil enzymes. (*In*) *Methods of Soil Analysis Part 2, Chemical and Microbiological Properties,* pp 903-47. AL Page (Ed.). American Society of Agronomy. Madison, WI.

Tarafdar J C and Marschner H. 1994. Efficiency of VAM hyphae in utilization of organic phosphorus by wheat plants. *Soil Science and Plant Nutrition* **40**: 593–600.

Verma N, Tarafdar J C, Srivastava K K and Panwar J. 2008. Arbuscular mycorrhizal (AM) diversity in *Prosopis cineraria* (L.) Druce under arid agroecosystems. *Agricultural Sciences in China* **7(6)**: 754–61.