American-Eurasian Journal of Scientific Research 1 (1): 38-41, 2006
ISSN 1818-6785

Increased Nutrient Uptake and Productivity of *Plantago ovata* Forssk by AM Fungi under Field Conditions

Nishi Mathur, Joginder Singh, Sachendra Bohra, Avinash Bohra and Anil Vyas

Microbial Biotechnology and Biofertilizer Laboratory, Department of Botany,
J.N.V. University, Jodhpur - 342001, Rajasthan, India

Abstract: Field experiments were conducted to evaluate potentiality of different arbuscular mycorrhizal fungi towards nutrient uptake and productivity of *Plantago ovata* under arid and semi arid conditions. Mycorrhizal inoculation resulted in significant increase in productivity of this multipurpose medicinal plant by improving nutrient uptake. Different AM fungi responded differently. Among seven AM fungi, *Glomus deserticola* found to be most efficient AM species for *Plantago ovata.* Details about symbiotic relationship are discussed.

Key words: Arbuscular mycorrhizal fungi · mycorrhizal inoculation · *Plantago ovata* · *Glomus deserticola*

INTRODUCTION

Plantago ovata is commonly grown as a cash crop in Rabi season in drought prone areas of arid and semi arid regions. Seed husk of this crop has medicinal value in treating intestinal disorders. Due to low cost of production and higher returns, the area under this crop is increasing rapidly in Indian Thar Desert. But its productivity is very low [1]. It is a short saturated, slow growing crop faces nutrient deficiency and scarcity of water resulting in poor yield. Crop production in the arid and semi arid environments is a highly unstable and unsustainable due to inhospitable climate and poor soil fertility status [2]. However, choice of proper technology for overcoming inhospitable climate factors may provide increased yield in the region.

Due to their ability to increase nutrient uptake and water transport arbuscular mycorrhizal fungi are being frequently used in sustainable agriculture [3]. AM fungi are frequently distributed arid and semi arid areas of Indian Thar Desert [4]. Increased productivity of different crops has been achieved using these biofertilizers [5]. Therefore, the present study was undertaken in order to apply AM fungi for increasing nutrient uptake and productivity of this multipurpose medicinal cash crop under field conditions.

MATERIALS AND METHODS

Soil preparation: Experiential plots of 10 x 10 feet were designed in the field to carry out present study. Soil of the field consisted of a sandy loam soil with the following chemical properties: pH 7.1; total N and C, 0.10 and 0.20g g^{-1}; available P, 8 mg kg^{-1}; K, Ca, Mg and Na, 70, 5.0, 3.0 and 0.25 c mol kg^{-1}, respectively. In each plot one feet layer of soil (twice autoclaved at 15 lb atm. pressure with 24 h gap) was sprayed.

Mycorrhizal fungal inoculum preparation: Four AM fungal species isolates and one non-mycorrhizal control were used in this study namely *Glomus mosseae* (Nicolson and Gerdemann) Gerdemann and Trappe; *Gigaspora margarita* Becker and Hall; *Acaulospora morrawae* Spain and Schenck & *Glomus deserticola* Trappe, Bloss & Menge All fungi were propagated in pot culture on roots of *Cenchrus ciliaris* grown in loam : sand (1 : 1) for 6 months. The non-mycorrhizal control was a similar culture without the AM fungi. Inocula consisted of a mixture of the soil medium, extraradical hyphae and spores and colonized root segments (2 mm in length).

Experimental design and plant maintenance: Mycorrhizal inoculation was done by layering method i.e., 5 cm layer of the above inoculum was spread in the beds before sowing the seeds. Seeds of *Plantago ovata* cultivar GI-2 were sown in rows. In each row seed to seed distance was of 10 inch and row-to-row distance in each experimental plant was kept up to 1 feet. Each bed was watered once a week without any addition of fertilizer. After 10 days of sowing seedlings emerged in each row. Seedlings were allowed to grow in the field. Samples were harvested after four months of sowing. Plant height was measured in cms

Corresponding Author: Dr. Anil Vyas, Microbial Biotechnology and Biofertilizer Laboratory, Department of Botany, J.N.V. University, Jodhpur - 342001, Rajasthan, India

Table 1: Influence of different arbuscular mycorrhizal fungi on biomass production and productivity of *Plantago ovata*

Treatments	Plant height (cm)	Spikes per plant	Spike length (cm)	1000 seed weight	Seed yield (kg ha^{-1})
Control	27.5	15.2	3.50	1.650	710
Acaul. mellaea	29.2	18.4	3.80	1.685	750
Gig. gigantea	32.4	24.2	4.52	1.755	790
G. fasciculatum	36.4	30.7	4.70	1.802	832
G. constrictum	33.6	27.5	4.63	1.780	820
G. deserticola	45.3	37.4	4.90	1.910	910
Scle. rubiformis	31.5	20.5	4.10	1.706	765
Scu. heterogama	41.2	34.2	4.82	1.825	850
CD at 5% level	3.02	2.70	0.20	0.030	20.5

Table 2: Influence of different arbuscular mycorrhizal fungi nutrient uptake of *Plantago ovata*

	mg g^{-1} Dry weight		µg g^{-1} Dry weight		
Treatments	Total-P	Total-N	Zn	Mn	Cu
Control	0.18	2.00	4.30	4.15	2.80
Acaul. mellaea	0.20	2.12	4.75	4.60	3.10
Gig. gigantea	0.26	2.70	5.32	5.26	3.50
G. fasciculatum	0.37	3.72	5.87	5.65	3.87
G. constrictum	0.32	3.25	5.60	5.42	3.65
G. deserticola	0.48	4.70	6.72	6.22	4.45
Scle. rubiformis	0.22	2.25	5.16	5.10	3.35
Scu. heterogama	0.42	4.32	6.20	5.80	4.15
CD at 5% level	0.02	1.20	1.20	1.20	1.30

while shoot weight and pod weight were recorded in terms of gram per plant. Roots were washed free of soil and dried briefly with paper towels before being weighed. A subsample was weighed and used for subsequent microscopic evaluation of AM colonization. AM colonization of *Plantago ovata* roots was assessed on 1 cm sections after clearing and staining by modified procedures of Phillips and Hayman [6], replacing lacto-phenol with lacto-glycerin. Using the grid line-intersect method [7], 100 intersections per sample were examined for the presence or absence of vesicles, internal hyphae and arbuscules. Colonization intensity was estimated rated visually for both intraradical structures and extraradical hyphae.

Physiological studies: Phosphorus and nitrogen were estimated in the plant tissues. Dry plant samples were first ground with the help of grinder and one gram ground sample was digested with 10 mL di.acid digestion mixture (HNO_3 : $HClO_4$; 9 : 4) and its volume was made up to 100 mL quantitatively. This was further used for estimation was estimated using the Vanadomolybdate method [8] while nitrogen was estimated by micro Kjeldhal method and K by flame photometer. The micronutrients were assayed using double beam atomic absorption spectrophotometer (GBC 902, Australia).

RESULTS AND DISCUSSION

Mycorrhizal inoculation resulted in increased biomass production and productivity of *Plantago ovata* as compared with non-mycorrhizal plants (Table 1). Different arbuscular mycorrhizal fungi showed differences in their potentiality to increase biomass production and productivity. The overall height of mycorrhizal plants varied from 29.2-45.3, while seed yield in different mycorrhizal treated plants ranged from 750-910 kg ha^{-1}. Among the seven AM species used during the present study *Glomus deserticola* responded most efficiently in increasing biomass production and productivity of *P. ovata* followed by *Scu. heterogama* whereas *Acaul. mellaea* resulted in minimum increase in these parameters. Treatment of *G. deserticola* resulted in more than 28 per cent increase in productivity of *P. ovata* under field conditions. The mycorrhizal inoculation also resulted in increased uptake of different nutrients as compared with non-mycorrhizal ones (Table 2). *G. deserticola* and *Scu. heterogama* both resulted in more than two-fold increase in uptake of P and N in *P. ovata* during the present study. Besides increasing uptake of these two nutrients AM fungi also resulted in increasing uptake of heavy metals like Zinc, Manganese and Copper in the host plant.

Increased nutrient uptake and productivity of field grown crops by mycorrhizal inoculation has been reported in banana [9], basil [10], corn [11], forage legumes [12], groundnut [13], tomato [14] and potato [15].

The effect AM fungi in the absorption of non-mobile nutrients, other than P by hyphal uptake and translocation towards the plant gave been reported. The evidence suggests that AM fungi might sequester heavy metals in the roots and thus reduce exposure to heavy metals [16]. Differences between fungi regarding root colonization, extra-cellular metal sequestration, metal uptake and translocation have been found [17, 18]. When considering inoculation with AM fungi in a heavy metal contaminated soil it is important to consider the intended strategy i.e. phytoextraction or increased plant tolerance to allow growth and production [19]. Increase uptake of heavy metals by AM fungi observed during present study could lead towards cultivation of *P. ovata* in heavy metal toxic soils, which may be useful for production of this multipurpose medicinal plant under adverse climatic conditions.

ACKNOWLEDGEMENT

The authors are thankful to CSIR, New Delhi for fianancial support.

REFERENCES

1. Anonymous, 1996. Area of production of isabgol in each district of Rajasthan (1994-95). Districtwise Trend of Agricultural Production in Rajasthan. Directorate of Economics and Statistics, Jaipur, Rajasthan, pp: 108.
2. Bohra, A., N. Mathur, J. Singh, S. Bohra and A. Vyas, 2005. Influence of indigenous AM fungi on nutrient uptake in different genotypes of Moth bean. J. Arid legumes, 2: 255-257.
3. Koide, R.T. and B. Mosse, 2004. A history of research on arbuscular mycorrhiza. Mycorrhiza, 14: 145-151.
4. Mathur, N. and A. Vyas, 2000. Mycorrhizal dependency of *Tamarix aphylla* in saline areas of Thar Desert. Naturalia, 25: 105-110.
5. Mathur, N., J. Singh, S. Bohra and A. Vyas, 2004. Relative efficiency of different AM fungi on nutrient uiptake and productivity of moth bean. J. Arid Legumes, 1: 135-137.
6. Phillips, J.F. and D.S. Hayman, 1970. Improved procedures for clearing root parasitic and staining vesicular arbuscular mycorrhizal fungi for rapid assessment of infection. Transaction British Mycological Society, 55: 158-160.
7. Giovannetti, M. and B. Mosse, 1980. An evaluation of techniques for measuring vesicular arbuscular mycorrhizal infection in roots. New Phytologist, 84: 489-500 and 108: 417-423.
8. Jackson, M.L., 1973. Plant tissue analysis-mineral constituents, In: Soil Chemical Analysis, Prentice Hall of India Ltd., New Delhi, pp: 326-338.
9. Yano-Melo, A.M., O.J. Saggin and L. Costa Maia, 2003. Tolerance of mycorrhizal banana (*Musa* sp. cv. *Pavocon*) plantlets to saline stress. Agriculture, Ecosystems and Environment, 95: 343-348.
10. Gupta, M.L., A. Khaliq, R. Pandey, R.S. Shukla, H.K. Singh and S. Kumar, 2000. Vesicular-arbuscular mycorrizal fungi associated with *Ocimum* spp. J. Herbs Spices Med. Plant, 7: 57-63.
11. Kaeppler, S.M., J.L. Parke, S.M. Mueller, L. Senior, C. Stuber and W.F. Tracey, 2000. Variation among maize inbred lines and detection of quantitative trait loci for growth at low phosphorus and responsiveness to arbuscular mycorrhizal fungi. Crop Sci., 40: 355-364.
12. Shockley, F.W., R.L. McGraw and H.E. Garrett, 2004. Growth and nutrient concentration of two native forage legumes inoculate with *Rhizobium* and mycorrhiza in Missouri, USA. Agroforestry Systems, 60: 137-142.
13. Lekberg, Y. and R.T. Koide, 2005. Arbuscular mycorrhizal fungi, rhizobia, available soil P and nodulation of groundnut (*Arachis hypogea*) in Zimbabwe. Agriculture, Ecosystems and Environment, 110: 143-148.
14. Gao, L.L., G. Delp and S.E. Smith, 2001. Colonization patterns in a mycorrhiza-defective mutant tomato vary with different arbuscular-mycorrhizal fungi. New Phytol. 51: 477-49l.
15. Davies, F.T., C.H. Calderon, Z. Huaman and R. Gomez, 2005. Influence of a flavonoid (formononetin) on mycorrhizal activity and potato crop productivity in the highlands of Peru. Scientia Horticulturae, 106: 318-329.
16. Joner, E.J. and C. Levyal, 1997. Uptake of ^{109}Cd by roots and hyphae of a *Glomus mosseae* / Trifolium subterranean mycorrhiza from soil amended with high and low concentrations of cadmium. New Phytologist, 135: 353-360.

17. Tonin, C., P. Vandenkoornhuyse, E.J. Joner, J. Straczek and C. Leyval, 2001. Assessment of arbuscular mycorrhizal fungi in the rhizosphere of *Viola calamainaria* and effect of these fungi on heavy metal uptake by clover. Mycorrhiza, 10: 161-168.
18. Leung, H.M., Z.H. Ye and M.H. Wong, 2006. Interactions of mycorrhizal fungi with *Pteris vittata* (As hyperaccumulator) in As-contaminated soils. Environmental Pollution, 139: 1-8.
19. Leyval, C., E.J. Joner, C. del Val and K. Haselwandter, 2002. Potential of arbuscular mycorrhizal fungi for bioremediation. In: Mycorrhizal Technology in Agriculture (Eds.) Gianinazzi, S., H. Schuepp, J.M. Barea and K. Haselwandter, Birkhauser Verlag, Switzerland, pp: 175-186.