Journal of Novel Applied Sciences
Available online at www.jnasci.org
©2014 JNAS Journal-2014-3-4/400-404
ISSN 2322-5149 ©2014 JNAS

Effect of arbuscular mycorrhiza fungi in agronomy

Mohammad Fahramand[1], Mohammad Adibian[2], Alireza Sobhkhizi[2], Mohsen Noori[2], Hossein Moradi[2] and Khashayar Rigi[1*]

1- Young Researchers and Elite Club, Zahedan Branch, Islamic Azad University, Zahedan, Iran
2- Higher Educational Complex of Saravan, Iran

Corresponding author: Khashayar Rigi

ABSTRACT: The bio inoculants help the expansion of root systems and better seed germination and plant growth. Improved productivity of AM plants was attributed to enhanced uptake of immobile nutrients such as phosphorus, zinc and copper. In addition, other factors associated with AM fungal colonization may influence plant resistance to drought. These include changes in leaf elasticity. Inoculation with arbuscular mycorrhiza fungi (AMF) has been found to increase the availability of phosphorous and other nutrients in crop plants because of its symbiotic associations with plant roots, colonizing cortical tissues and extending hyphae into the rhizosphere. AM fungi are especially important for sustainable farming systems because AM fungi are efficient when nutrient availability is low and when nutrients are bound to organic matter and soil particles.

***Keywords*:** Nutrients, Negative impact, Positive effects.

INTRODUCTION

Integrated nutrient management strategies involving chemical fertilizers and bio-fertilizers have been suggested to enhance the sustainability of crop production (Manske. 1998). The bio inoculants help the expansion of root systems and better seed germination and plant growth (Manske. 1995). In African soils, legume as a pre-crop also affects the biological properties: legume pre-crops result in earlier colonisation of cereal roots by AM fungi (Bagayoko, 2000). Inoculation of plant roots with arbuscular mycorrhizal (AM) fungi may be effective in improving crop production under drought conditions. Colonization of roots by AM fungi has been shown to improve productivity of numerous crop plants in soils under drought stress (Al- Karaki and Al-Raddad 1997; Al-Karaki and Clark 1998; Faber. 1990; Sylvia. 1993). Improved productivity of AM plants was attributed to enhanced uptake of immobile nutrients such as phosphorus, zinc and copper. In addition, other factors associated with AM fungal colonization may influence plant resistance to drought. These include changes in leaf elasticity (Auge. 1987a), improved leaf water and turgor potentials, maintenance of stomatal opening and transpiration (Auge. 1987b), increased root length and depth, and development of external hyphae (Ellis. 1985; Davies. 1992).

Phosphorous and other nutrients

Inoculation with arbuscular mycorrhiza fungi (AMF) has been found to increase the availability of phosphorous and other nutrients in crop plants because of its symbiotic associations with plant roots, colonizing cortical tissues and extending hyphae into the rhizosphere (Hetrick, 1996). Mycorrhizae have reportedly increased nutrient uptake, salinity tolerance, drought tolerance, water uptake, root disease resistance, and photosynthesis (Srivastava, 1996; Sharma, 1994). Mycorrhizal extension of the plant root surface facilitates potential uptake and translocation of P, nitrogen (N), K, Ca, sulfur (S), Cu, molybdenum (Mo), and Zn (Srivastava, 1996; Singer and Munns, 1987; Azcon-Aguilar and Barea, 1992; Sharma and Srivastava, 1991; Sharma, 1994; Lambert and Weidensaul, 1991; Burkert and Robson, 1994; Hamilton, 1993; Swaminathan and Venna, 1979; Frey and Ellis, 1997). Because Zn availability can be low in neutral to alkaline soils due to adsorption on aluminum (Al) and Fe oxides, clay minerals, organic matter, and CaCO3 (Tisdale, 1993), mycorrhizae in these soils could potentially benefit plants. High fertilizer application generally decreases the mycorrhizal impact on nutrient uptake (Ellis, 1992).

Negative impact

It is well known that AM fungi enhance plant growth. However, AM fungi are not only beneficial and interactions between plants and AM fungi can range from mutualistic to parasitic (van der Heijden 2002; Klironomos 2003). Studies performed with plants from natural communities show that AM fungi have a negative impact on several ruderal plants (Francis & Read, 1995). Many important weeds have a ruderal lifestyle, suggesting that AM fungi have the potential to suppress weed growth.

The responsiveness of wheat varieties

The responsiveness of wheat varieties in terms of improved performance of different traits to microbes greatly differs and these differences are due to the genetic background of the varieties (Behl, 2003). Wheat genotypes having improved root length density (RLD), a large number of spikes per m^2 and seed weight support microbe symbiosis in low input environment (Manske, 2000).

Symbiosis

The symbiosis between plants and mycorrhizal fungi is extremely widespread and ancient in the plant kingdom. Root colonization with mycorrhizal fungi occurs in >80% of all plant species (Smith and Read, 1997) and has been observed in fossils dating back 400 million years ago (Remy and Taylor, 1994).

Root colonization

Root colonization with mycorrhizal fungi generally has positive effects on plant growth (Chalk, 2006) and mycorrhizal inoculation is frequently applied to increase crop plant productivity in agricultural systems (Li, 2000, 2004; Ortas, 2003; Ortas, 2010).

Positive effects

Positive effects of mycorrhiza on plants include increases in height (Hayman, 1986; Hoeksema, 2010; Safapour, 2011), biomass (Vejsadova, 1993; Mathur and Vyas, 2000; Ramana, 2010), shoot: root ratio (Gavito, 2000; Veresoglou, 2012), production of flowers (Dodd, 1983; Carey, 1992), and yield in crop plants such as Phaseolus vulgaris, Glycine max, and Triticum aestivum (Vejsadova, 1993; Bethlenfalvay, 1997; Abdel-Fattah, 1997; Li, 2005; Ramana, 2010; Safapour, 2011). AM fungi can act as support systems for seedling establishment, provide resistance against drought and some pathogens, and AM fungi can enhance biological diversity in grassland (van der Heijden, 1998). Several studies have shown that AM fungi contribute to up to 90% of plant P demand (Jakobsen. 1992; van der Heijden. 2006).

Sustainable farming

AM fungi are especially important for sustainable farming systems because AM fungi are efficient when nutrient availability is low and when nutrients are bound to organic matter and soil particles. Many important agricultural crops can benefit from AM fungi, including maize, potato, sunflower, wheat, onion, leek and soybean, especially under conditions where nutrient availability is limiting plant growth. Moreover, AM fungi not only can promote via directs effects, but there are also a number of indirect effects such as a stimulation of soil quality and the suppression of organisms that reduce crop productivity (Dodd, 1983; Carey, 1992).

MATERIALS AND METHODS

This paper is a review of the literature search on ISI, Scopus and the Information Center of Jahad and MAGIRAN SID is also abundant. Search library collection of books, reports, proceedings of the Congress was also performed. All efforts have been made to review articles and abstracts related to internal and external validity.

RESULTS AND DISCUSSION

Propagation:

n presence of synthetic vinyl monomer, pregelled starch radical is added to the double bond of the vinyl monomer, resulting in a covalent bond between monomer and pregelled starch with creation of a free radical on the monomer, i.e., a chain is initiated. Subsequent addition of monomer molecules to the initiated chain propagates the grafting reaction onto pregelled starch as follows:

Termination:

Finally, termination of the growing grafted chain may occur via reaction with the initiator, coupling or combination and disproportionation as follows:

Effect of methacrylamide concentration:

Figureure 2 declares the effect of changing MAam concentration on the percent graft yield of poly (MAam) - pregelled starch graft copolymer using the optimum 120 S exposure time obtained above in section 3.1.1. Details of the conditions used are given in the text. It is clear from the drown data that there is a direct relation between the percent graft yield and monomer concentration within the experimental range studied, the higher the MAam concentration the greater availability of the latter in the vicinity of pregelled starch as well as the molecular collision of the reactants. Beside, the microwave radiation rotates the methacrylamide molecules, leading to elongation of its C-C double bond at which the pi bond electron cloud splits up into two localized clouds (i.e. free radical sites on the basic carbon atoms). Both the free radical sites that created on the pregelled starch backbone and that on the methacrylamide by microwave radiation interacts through common free radical reaction mechanism, to yield poly (methacrylamide) - pregelled starch graft copolymer.

Effect of microwave irradiation power:

Figureure 3 clarifies the effect of microwave irradiation power as one of the powerful controlling factors affect the percent graft yield of poly (MAam) - pregelled starch graft copolymer using 120 S exposure time and 4 g methacrylamide concentration. To optimize the microwave power, reaction was preceded from 150 to 600 W. It is clear that, the percent graft yield increases initially with increasing microwave power up to 500 W then decreases thereafter. This can be explained in the manner of, when the microwave radiation power increases up to 500 W, the rotation of the methacrylamide molecules increased, which leads to more and more elongation of its bond. As the C-C double bond elongates more, the pi bond electron cloud splits up into two localized clouds (i.e. free radical sites on the constituent carbon atoms). Both the free radical sites thus created on the pregelled starch backbone and that on the methacrylamide by microwave radiation interacts rapidly through usual free radical reaction mechanism, to yield higher graft yields of the prepared copolymer. Saying on other word, higher grafting may be account to the more availability of microwave energy at higher microwave power, which causes more and more monomer and macro radical generation. On the other hand, after 500 W microwave power, the decrease in percent graft yield may be attributed to more homopolymer formation at higher microwave powers or to some decomposition of the graft copolymer at higher microwave power.

REFERENCES

ABDEL-FATTAH GM. 1997. Functional activity of VA-mycorrhiza (Glomus mosseae) in the growth and productivity of soybean plants grown in sterilized soil. Folia. Microbiol. 42, 495-502.

Al-Karaki GN and Al-Raddad A. 1997. Effects of arbuscular mycorrhizal fungi and drought stress on growth and nutrient uptake of two wheat genotypes differing in drought resistance. Mycorrhiza 7:83–88

Al-Karaki GN and Clark RB. 1998. Growth, mineral acquisition, and water use by mycorrhizal wheat grown under water stress. J Plant Nutr 21:263–276

Auge RM, Schekel KA and Wample RL. 1987a. Rose leaf elasticity changes in response to mycorrhizal colonization and drought acclimation. Physiol Plant 70:175–182

Auge RM, Schekel KA and Wample RL. 1987b. Leaf water and carbohydrate status of VA mycorrhizal rose exposed to drought stress. Plant Soil 99:291–302

Bagayoko M, Buerkert A, Lung G, Bationo A and Roemheld V. 2000. Cereal/legume rotation effects on cereal growth in Sudano-Sahelian West Africa: Soil mineral nitrogen, mycorrhizae and nematodes. Plant and Soil 218, 103-116.

Bethlenfalvay GJ, Schreiner RP and Mihara KL. 1997. Mycorrhi-zal fungi effects on nutrient composition and yield of soybean seeds. J. Plant Nutr. 20, 581-591.

Burkert B and Robson A. 1994. 65Zn uptake in subterranean clover (Trifolium subterraneum L.) by three vesicular-arbuscular mycorrhizal fungi in a root-free sandy soil. Soil Biol. Biochem. 26:1117-1124.

Carey PD, Fitter AH, Watkinson AR, Url S and Carey D. 1992. A field study using the fungicide benomyl to investigate the effect of mycorrhizal fungi on plant fitness. Oecologia 90, 550-555.

Chalk P, Souza R, Urquiaga S, Alves B and Boddey R. 2006. The role of arbuscular mycorrhiza in legume symbiotic performance. Soil Biol. Biochem. 38, 2944-2951.

Davies FT Jr, Potter JR and Linderman RG. 1992. Mycorrhiza and repeated drought exposure affect drought resistance and extraradical hyphae development on pepper plants independent of plant size and nutrient content. J Plant Physiol 139:289–294
Dodd J, Krikun J and Haas J. 1983. Relative effectiveness of indigenous populations of vesicular-arbuscular mycorrhizal fungi from four sites in the Negev. Isr. J. Bot. 32, 10-21.
Ellis JR, Larsen HJ and Boosalis MG. 1985. Drought resistance of wheat plants inoculated with vesicular-arbuscular mycorrhizae. Plant Soil 86:369–378
Ellis JR, Roder W and Mason SC. 1992. Grain sorghum-soybean rotation and fertilization influence in vesicular-arbuscular mycorrhizal fungi. Soil Sci. Soc. Am. J. 56:789-794.
Faber BA, Zasoski RJ, Burau RG and Uriu K. 1990. Zinc uptake by corn as affected by vesicular-arbuscular mycorrhizae. Plant Soil 129:121–130
Francis R and Read DJ. 1995. Mutualism and antagonism in the mycorrhizal symbiosis, with special reference to impacts on plant community structure. Can. J.Bot. 73, S1301-S1309.
Frey JE and Ellis JR. 1997. Relationship of soil properties and soil amendments to response of Glomus intraradices and soybeans. Can. J. Bot. 75:483-491.
Gavito ME, Curtis PS, Mikkelsen T and Jakobsen I. 2000. Atmospheric CO(2) and mycorrhiza effects on biomass allocation and nutrient uptake of nodulated pea (Pisum sativum L.) plants. J. Exp. Bot. 51, 1931-1938.
Hamilton MA, Westermann DT and James DW. 1993. Factors affecting zinc uptake in cropping systems. Soil. Sci. Soc. Am. J. 57:1310-1315.
HAYMAN DS. 1986. Mycorrhizae of nitrogen-fixing legumes. MIRCEN. J. Appl. Microbiol. Biotechnol. 2, 121-145.
Hetrick BAD, Wilson GWT and Todd TC. 1996. Mycorrhizal response in wheat cultivars: relationship to phosphorus. Can. J. Bot., 74: 19–25.
Hoeksema JD, Chaudhary VB, Gehring CA, Johnson NC, Karst J, Koide RT, Pringle A, Zabinski C, Bever JD, Moore JC, Wilson GWT, Klironomos JN and Umbanhowar J. 2010. A meta-analysis of context-dependency in plant response to inoculation with mycorrhizal fungi. Ecol. Lett. 13, 394-407.
Jakobsen I, Abbott LK and Robson AD. 1992. External hyphae of vesicular-arbuscular mycorrhizal fungi associated with *Trifolium subterraneum* L. I: Spread of hyphae and phosphorus inflow into roots. New Phytol., 120, 371-380.
Klironomos JN. 2003. Variation in plant response to native and exotic arbuscular mycorrhizal fungi. Ecology 84: 2292-2301.
Lambert DH and Weidensaul TC. 1991. Elemental uptake by mycorrhizal soybean from sewage-sludge-treated soil. Soil Sci. Soc. Am. J. 55:393-398.
Li HY, Zhu YG, Marschner P, Smith FA and Smith SE. 2005. Wheat responses to arbuscular mycorrhizal fungi in a highly calcareous soil differ from those of clover, and change with plant development and P supply. Plant Soil 277, 221-232.
Li M, Liu RJ and Li XL. 2004. Influence of arbuscular mycorrhizal fungi on growth and Fusarium-wilt disease of watermelon grown in the field (in Chinese). Acta. Phytotaxon. Sin. 34, 456-457.
Li M, Meng XX, Jiang JQ and Liu RJ. 2000. A preliminary study on relationship between arbuscular mycorrhizal fungi and Fusarium wilt of watermelon (in Chinese). Acta. Phytotaxon. Sin. 30, 327-331.
Manske GGB, Behl RK, Luttger AB and Vlek PLG. 1998. Enhancement of mycorrhizal (AMF) infection, nutrient efficiency and plant growth by Azotobacter chroococcum in wheat. Evidence for varietal effects. In: Narula N. (ed.): Azotobacter in sustainable agriculture. CBS Publ. Distrib., New Delhi: 136–147.
Manske GGB, Luttger AB, Behl RK and Vlek PLG. 1995. Nutrient efficiency based on VA mycorrhiza (VAM) and total root length of wheat cultivars grown in India. Angew. Bot., 69: 108–110.
Manske GGB, Qritz-Monasterio JI, Ginklel van M, Gozzalez RM, Rajaram S, Molina E and Vlek PLG. 2000. Traits associated with improved P-uptake efficiency in CIMMYTs semi dwarf spring bread wheat grown on an acid Andisol in Mexico. Pl. Soil, 221: 189–204.
Ortas I. 2010. Effect of mycorrhiza application on plant growth and nutrient uptake in cucumber production under field conditions. Span. J. Agric. Res. 8, 116-122.
Ortas I, Sari N and Akpinar C. 2003. Effects of mycorrhizal inoculation and soil fumigation on the yield and nutrient uptake of some solanaceas crops (tomato, eggplant and pepper) under field conditions. Agric. Mediterr. 133, 249-258.
Ramana V, Ramakrishna M, Purushotham K and Reddy KB. 2010. Effect of bio-fertilizers on growth, yield attributes and yield of french bean (Phaseolus vulgaris L.). Legume. Res. 33, 178-183.
Reinhard S, Martin P and Marschner H. 1993. Interactions in the tri-partite symbiosis of pea (Pisum sativum L.), Glomus and Rhizobium under non-limiting phosphorus supply. J. Plant Physiol. 141, 7-11.
Remy W and Taylor T. 1994. Four hundred-million-year-old vesicular arbuscular mycorrhizae. Proc. Natl. Acad. Sci. USA. 91, 11841-11843.
Safapour M, Ardakani M, Khaghani S, Rejali F, Zargary K, Changizi M and Teimuri M. 2011. Response of yield and yield components of three red bean (Phaseolus vulgaris L .) genotypes to co-inocu-lation with Glomus intraradices and Rhizobium phaseoli. Am. Eurasian. J. Agric. Environ. Sci. 11, 398-405.
Sharma AK, Srivastava PC and Johri BN. 1994. Contribution of VA mycorrhiza to zinc uptake in plants. pp. 111-124. In: J.A. Manthey, D.E. Crowley, and D.G. Luster (eds.), Biochemistry of Metal Micronutrients in the Rhizosphere. Lewis Publishers, Boca Raton, FL.
Singer MJ and Munns DN. 1987. Soils: An Introduction. Macmillan Publishing Company, New York, NY.
Smith S and Read D. 1997. Mycorrhizal symbiosis, 2nd edn., Academic Press, San Diego.

Srivastava D, Kapoor R, Srivastava SK and Mukerji KJ. 1996. Mycorrhizal research A priority in agriculture. pp. 41-75. In: K.G. Mukerji (ed.), Concepts in Mycorrhizal Research. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Swaminathan K and Verma BC. 1979. Responses of three crop species to vesiculararbuscular mycorrhizal infection on zinc-deficient Indian soils. New Phytol. 82:481- 487.

Sylvia DM, Hammond LC, Bennett JM, Haas JH and Linda SB. 1993. Field response of maize to a VAM fungus and water management. Agron J 85:193–198

Tisdale SL, Nelson ML, Beaton JD and Havlin JL. 1993. Soil Fertility and Fertilizers. 5th ed. Macmillan Publishing Company, New York, NY.

Van der Heijden MGA, Klironomos JN, Ursic M, Moutoglis P, Streitwolf-Engel R, Boller T, Wiemken A and Sanders IR. 1998. Mycorrhizal fungal diversity determines plant biodiversity, ecosystem variability and productivity. Nature 396: 72-75.

van der Heijden MGA, Streitwolf-Engel R, Riedl R, Siegrist S, Neudecker A, Ineichen K, Boller T, Wiemken A and Sanders IR. 2006. The mycorrhizal contribution to plant productivity, plant nutrition and soil structure in experimental grassland. New Phytol. 172: 739-752.

Van der Heijden MGA. 2002. Arbuscular mycorrhizal fungi as a determinant of plant diversity: in search for underlying mechanisms and general principles. In: van der Heijden MGA, Sanders IR. ed. Mycorrhizal Ecology. Ecological Studies 157. Springer Verlag, Heidelberg, Germany.

Veresoglou SD, Menexes G and Rillig MC. 2012. Do arbuscular mycorrhizal fungi affect the allometric partition of host plant biomass to shoots and roots? A meta-analysis of studies from 1990 to 2010. Mycorrhiza 22, 227-235.