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Inoculation of Soybeans with mycorrhizal Fungi in the Field of Central Asia

Boymatova M[1] and Umarov B[2]*

[1]*National Center for Knowledge and Innovation in Agriculture Rice Scientific Research Institute, Ministry of Agriculture, Republic of Uzbekistan*

[2]*Tashkent Research Institute of Vaccines and Serum, Ministry of Health, Republic of Uzbekistan*

ABSTRACT

The influence of arbuscular mycorrhiza (AM) fungi inoculation on growth performance of legume plants was studied in a greenhouse experiment. The results obtained indicated the dependence of Soybeans on mycorhizal symbiosis. Inoculation with arbuscular mycorrhiza significantly improved the growth performance of Soybean. The height growth increased significantly by 85% after only three months. Shoot production increased by 213% while root biomass increased by 241%. Inoculation with arbuscular mycorrhiza increased plant tissue phosphorus, nitrogen and potassium content. The better growth response of mycorrhizal plants was attributed to improvement in nutrient uptake, especially phosphorous, nitrogen and potassium. Arbuscular mycorrhiza inoculation has a high potential in agriculture as a biofertilizer.

KEYWORDS: Symbioses; AM fungi; Soybean

INTRODUCTION

Mycorrhizae result from symbiotic associations between soil fungi and the roots of most plants. Mycorrhizae are considered to be classic examples of mutualistic symbioses. The basis for this mutualism relies on the supply of carbon to the fungus by the host plant and, in return, on the supply of mineral nutrients and water to the plant and on the plant's protection against soil-borne diseases by the fungus. Among mycorrhizal symbioses, arbuscular mycorrhizae (AM) are the most widespread. AM are recorded in 80% of land plants and are generated by the association of plant roots and fungal populations belonging to the Glomeromycotan phylum, which includes around 160 species. AM are ancient; the first fossil evidence of this symbiosis dates back 400 million years. Several authors have proposed that AM have contributed to the colonization of early land plants. AM are generally assumed to be nonspecific associations, since Glomeromycotan are able to colonize roots of several host plants and are themselves colonized by different AM fungal species. Despite this lack of host specificity, the diversity of AM fungi has been shown to affect the plant community composition under field conditions and the genetic structure of the AM fungal community was shown to differ significantly according to the plant species. The long, joint evolution of plants and AM fungi is expected not to have occurred independently of the resident bacterioflora [1].

MATERIALS AND METHODS

The experiment was conducted in a green house. The experiment was design, with three replicates The soil was air dried, pulverized and passed through a 2mm sieve and was sterilized by avtoclav under 121 ^{0}C for 30 minutes at 0,5 atmosphere. The soil had an initial pH of 5.0. were used pots with 20cm clay, and for all pots were used of 4 plants. The mycorrhizal fungi inoculants consisting of spores, mycorrhizal root fragments and infected soil was collected from pot cultures of plants leguminous which had been grown for five months after being inoculated with mycorrhiza fungus species. The seeds were germinated in sterilized river sand. After the seedlings had developed two leaves each, four seedlings were transplanted to each clay pot containing the sterilized soil, with arbuscular mycorrhiza inoculum.

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Address for correspondence: Boymatova M, National Center for Knowledge and Innovation in Agriculture Rice Scientific Research Institute. Ministry of Agriculture, Republic of Uzbekistan

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To determine the effect of arbuscular mycorrhiza inoculation inoculated and non-inoculated legume plants were raised in a greenhouse for three months. Height growth was measured after every 15 days, except during the first months. After 100 days, 50% of the plants were harvested. At the end of four month, some plants were harvested randomly per treatment and arbuscular mycorrhiza infection level was assessed. For the plant tissue nutrient content, above ground biomass was harvested and was oven dried at 70 ^{0}C. The plant tissues were then analyzed for total nitrogen. The numbers and length of primary roots per plants were assessed and determined. The measured plants parameters were analysed.

RESULTS AND DISCUSSION

The results obtained indicated the dependence of Soybean mycorrhiza symbiosis. The effect of arbuscular mycorrhiza inoculation on the height increment was obvious on visual comparison at the end of 90 days. The enhanced height increment in Soybean could be attributed to the arbuscular mycorrhiza colonization. Mycorrhiza inoculation is known to enhance plant growth by increasing nutrients uptake of nitrogen, phosphorus and potassium is limited by the rate of diffusion of each nutrient through the soil [2]. It seems likely that arbuscular mycorrhiza in this study increased nutrient uptake by shortening the distance nutrients diffused through the soil to the roots. During the first 45 days, there was small difference in height increment between inoculated and non-inoculated plants, although the height increment in inoculated plants was higher. This could be due to the "lag phase" effect of mycorrhiza inoculation. Many studies have shown that there is a lag phase between mycorrhiza inoculation and the time period when its effect is manifested in the plant [3]. At the end of ninety days, height growth of inoculated Soybean was highly significant as compared to the non-inoculated plants. The higher height increment registered with inoculated plants could be as a result of enhanced inorganic nutrient absorption and greater rates of photosynthesis [4]. Arbuscular mycorrhizas are known to affect both the uptake and accumulation of nutrients and therefore, act as important biological factors that contribute to efficiency of both nutrient uptake and use. Researchers have demonstrated that arbuscular mycorrhiza fungi, not only increases phosphorus uptake, but also plays an important role in the uptake of other plant nutrients and water inflows of phosphorus to mycorrhiza roots can be greater than inflows to comparable non-mycorrhiza roots by up to 2-5 times [5].

Shoot Biomass

Inoculating Soybean with arbuscular mycorrhizal fungi significantly increased the shoot biomass yield. The shoot biomass production increased by 213% and was highly significant. The highly significant shoot biomass production by the inoculated plants, could be attributed to enhanced inorganic nutrition absorption and greater rates of photosynthesis in inoculated plants [6]. Arbuscular mycorrhizal fungi are reported [7] to enhance plant growth rate through an increase in nutrient uptake, especially phosphorus which is relatively immobile in soils. Arbuscular mycorrhiza inoculation could have enhanced Soybean to absorb more nutrients via an increase in the absorbing surface area. Similar observation has been reported with another scientist [8].

Root Biomass

The movement of nutrients to plant roots and the rate of absorption of nutrients by roots, especially nitrogen, phosphorus, and potassium, is known to be limited by the rate of diffusion of each nutrient through the soil and not by the ability of the root to absorb the nutrient from low concentration in the soil solutions [9]. In picture 1, A and B shown, inoculating Soybean with Arbuscular mycorrhiza significantly increased the soot length and root, soot biomass production. Arbuscular mycorrhiza infection has been reported to increase both the uptake of nutrients by the roots and the concentration of nutrients in the plant tissues [10]. An increase in nutrient uptake, especially phosphorus in the poor soil used, could have resulted in relief of nutrients stress and an increase in photosynthetic rate, which obviously could have given rise to an increase in plant growth. Research has shown that when root exploration is restricted, up to 80% of the plant phosphorus can be delivered by the external arbuscular mycorrhizal hyphae to the host plant over a distance of more than 10 cm from the root surface [11]. Inoculating Soybean with arbuscular

mycorrhiza fungi significantly increased the root length (Figure 1). The inoculation with AM increased the root length by 25%. Mycorrhiza inoculation is known to enhance the plants absorption of more nutrients especially phosphorus via an increase in the absorbing surface area. This in turn could have enhanced a higher plant growth rate resulting to more roots per plant. Mycorrhiza colonization also protect the roots from the soil pathogens and, therefore could have led to an increase in not only the root growth and nutrient acquisition of the host roots, but also the number of surviving roots [12].

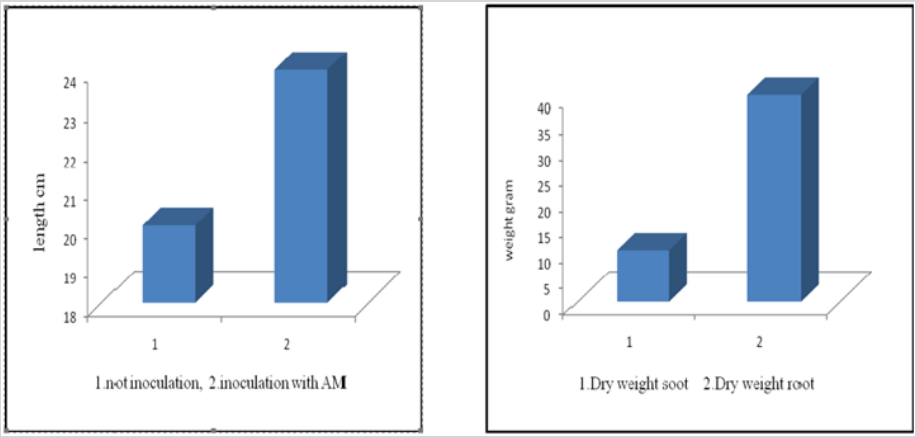

Figure 1: Effects of Mycorrhizal fungi inoculation with Soybean in the green house. MED (Minimal Essential Difference) test. t = 0, 86, t > 0, 05, *P* = 0, 01%

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Root to Shoot Ratio

The difference between the root to shoot ratio of inoculated and non-inoculated Soybean, was not statistically significant at 5% level though the inoculated Soybean had a higher root to shoot ratio as compared to non-inoculated plants. The higher root to shoot ratio of the inoculated plants could be attributed to the effect of mycorrhiza infection, which could have increased nutrients absorption, giving rise to a higher root and shoot biomass increment with a uniform growth.

Plant Tissue Nutrients Concentration

In the Soybean after 90 days of phosphorus, nitrogen and potassium concentration was much higher in the inoculated plants than non-inoculated ones. The higher phosphorus concentration in the inoculated plants could be attributed to a higher nutrients absorption rate by mycorrhiza plants. Several authors have reported that mycorrhizal roots are able to absorb several times more phosphate than non-inoculated roots from soils and from solutions [13]. Increased efficiency of phosphorus uptake by mycorrhizal plants could have led to higher concentrations of P in the plant tissues. The greater phosphate absorption by arbuscular mycorrhizae has been suggested to have arisen due to superior efficiency of uptake from labile forms of soil phosphate, which is not attributable to a capacity to mobilize phosphate sources unavailable to non-mycorrhizal roots [14].

CONCLUSION

The current study had shown that inoculating Soybean with arbuscular mycorrhiza enhances growth performance. The inoculation resulted in an increment in height growth by 85% and root by 71% within three months. Shoot biomass increased significantly by 213% while root biomass increased by 241%. Inoculated plants subsequently produced more leaves per plant, which could have increased the rate of photosynthesis. Inoculated plants produced also more roots per plant which were longer than in the non-inoculated plants. This improvement in plant growth could be attributed to the enhancement of the plant to absorb more nutrients, via an increase in the absorbing surface area. Arbuscular mycorrhiza colonization also protects roots from soil pathogens and thereby increase root growth and nutrients acquisition of the host plants.

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