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Sustainable Production of Corn (*Zea mays*) by Seed Inoculation with Mycorrhiza Strains

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Abstract: In order to sustainable production of corn by seed inoculation with Mycorrhiza strains a factorial field experiment was conducted during 2010-2011. Studied factors were Mycorrhiza strains (*Glomus intraradics* and *G. mosseice*) and phosphorous fertilization included 33%, 67% and 100% of recommended dose of super phosphate triple. There was a field with neither inoculation with Mycorrhiza nor phosphorous fertilization as control. Results revealed that the effects of Mycorrhiza strains and phosphorous fertilization on crop height were significant. When seeds inoculated with Mycorrhiza strains, corn plants were taller than non-treated ones. The corn seeds inoculated with *G. intraradics* and *G. mosseice* had higher LAI than check plants. Maximum LAI obtained from crop plants fertilized with 67% recommended dose of phosphorous and these plants could improve their LAI up to 3.65. In non-inoculated seeds with increasing of phosphorous fertilization rate grain yield improved, significantly and yield produced in 100% recommended dose of phosphorous was nearly 6.43 tha^{-1}. Whereas, in those seeds inoculated with Mycorrhiza strains and fertilized with 67% recommended dose of phosphorous, yield improved 31%. Higher grain phosphorous content was observed in treatments of 67% recommended dose of phosphorous plus inoculated seeds. Increasing of grain phosphorous content in non-biofertilized seeds experiencd linear trend with increasing of phosphorous application rate. Corn seeds biofertilization with both *G. intraradics* and *G. mosseice* Mycorrhiza strains may reduce in phosphorous fertilizer application rate in semi-arid regions and it can be resulting in reduction of fertilizers environmental hazards in sustainable maize production.

Key words: Environmental hazard · Mycorrhiza · Recommended dose · Sustainable maize production.

INTRODUCTION

A Mycorrhiza is a symbiotic (generally mutualistic, but occasionally weakly pathogenic) association between a fungus and the roots of a vascular plant. In a mycorrhizal association, the fungus colonizes the host plant's roots, either intra-cellularly as in arbuscular mycorrhizal fungi (AMF), or extra-cellular as in ecto-mycorrhizal fungi [1]. Fungal symbioses have been defined as "all associations where fungi come into contact with living host from which they obtain, in a variety of ways, either metabolites or nutrients". However, this definition excludes mycorrhizal associations of myco-heterotrophic plants, where plants are nutritionally dependant on fungi. A mycorrhizal plant can uptake 100 times or more nutrients than one without the beneficial fungi. The addition of mycorrhizal fungi spores to transplant roots, garden soils, potting soil, lawns, or seeded crops will ensure the presence of these valuable plant allies [2, 3].

Phosphorus is one the most essential elements for plant growth after nitrogen. However, the availability of this nutrient for plants is limited by different chemical reactions especially in arid and semi-arid soils [4]. Phosphorus plays a significant role in several physiological and biochemical plant activities like photosynthesis, transformation of sugar to starch and transporting of the genetic traits.

Sharma [5] reported that one of the advantages of feeding the plants with phosphorus is to create deeper and more abundant roots. Phosphorus causes early ripening in plants, decreasing grain moisture, improving crop quality and is the most sensitive nutrient to soil pH [6]. Malakooti and Nafisi [7] declared that the best pH for

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phosphorous uptake by plants is 6.5. Arpana *et al*. [8] reported that a great proportion of phosphorus in chemical fertilizer becomes unavailable to the plants after its application in the soil. They referred this to formation of strong bonds between phosphorous with calcium and magnesium in alkaline pH and the same bonds with iron and aluminum in acidic soils. The mobility of this element is very slow in the soil and cannot respond to its rapid uptake by plants [9].

The study was conducted for sustainable production of corn by seed inoculation with Mycorrhiza strains.

MATERIALS AND METHODS

A factorial field experiment was conducted during 2010-2011 at Miandoab, (Lat. 34°, 5´; Long. 46°, 17´ and elevation 1210 m), Iran, in a sandy loam soil with pH of 7.7 and organic matter of 1%, on grain corn, variety, *540*. Miandoab located at the north-west of Iran and the climate is semi-arid and cold. The experimental field had been in a sugar beet-barley rotation cycle for the last two years. The experimental area was ploughed in the fall and manured with 15 t ha^{-1}. Fields were cultivated, disked, furrowed and then plotted in the early spring before sowing the seeds. Full dose of fertilizers used in spring and before sowing, were 150 and 200 kg ha^{-1} of ammonium phosphate and urea, respectively. The plots were 2.5 by 4 m^{-2}.

Studied factors were Mycorrhiza strains (*Glomus intraradics* and *G. mosseice*) and phosphorous fertilization included 33%, 67% and 100% of recommended dose of super phosphate triple. There was a field with neither inoculation with Mycorrhiza nor phosphorous fertilization as control. All data were statistically analyzed based on randomized complete block design using MSTAT-C software. The means of the treatments were compared using the least significant difference test at * $P < 0.05$.

RESULTS AND DISCUSSION

Crop Height: Effects of Mycorrhiza strains and phosphorous fertilization on crop height were significant at 1% probability level (Table 1). When seeds inoculated with Mycorrhiza strains, corn plants were taller than non-treated ones (Figure 1). On the other hand, stem height in treated plants increased nearly 8-cm compared to the control. Similar results were reported by Talukdar and Germidar [10] on lentil. It was indicated that application of 67% recommended dose of super phosphate triple was more effective than other phosphorous levels on increasing of stem height (Table 2). In this experiment stem height was 8.5% taller, as compared to non-fertilized ones, which Dodd [11] also emphasizes on it.

LAI: Interaction of Mycorrhiza strains and phosphorous fertilization on crop LAI was not significant (Table 1). Mean comparisons revealed that seeds inoculated with *G. intraradics* and *G. mosseice* had higher LAI than check plants (Figure 2). Mycorrhizal inoculated plants have higher capability to water and nutrients absorption. So, these plants have greater photosynthesis rate and assimilates accumulation [12, 10]. In another study conducted by Thakur and Panwar [13] on bean, seed biofertilization with *Rhizobium* and Mycorrhiza (*Glomus*) could increase crop LAI and chlorophyll content index by 9% and 11%, respectively. Maximum LAI obtained from crop plants fertilized with 67% recommended dose of phosphorous and these plants could improve their LAI up to 3.65 (Table 2).

Grain Yield: Interaction of Mycorrhiza strains and phosphorous fertilization on grain yield were significant at 1% probability level (Table 1). In non-inoculated corn seeds with increasing of phosphorous fertilization rate grain yield improved, significantly and yield produced in 100% recommended dose of phosphorous was nearly

Table 1: Variance analysis of effects of Mycorrhiza strains and phosphorous fertilization on studied traits in corn.

		MS			
SV	df	Crop height	LAI	Grain yield	Grain phosphorous content
R	2	42.72	0.017	2.13	0.0001
Mycorrhiza strains (M)	2	190.13**	0.536**	11.90**	0.005**
Phosphorous (P)	3	621.20**	1.640**	31.95**	0.014**
M × P	6	41.71	0.131	2.25**	0.002**
Error	22	18.20	0.10	0.24	0.0001
CV (%)	-	18.00	10.11	5.24	7.39

*, ** Mean significant difference at 5% and 1% probability levels, respectively.

Table 2: Mean comparisons of corn stem height and LAI at different phosphorous application levels.

phosphorous application levels (% of recommended dose)	0	33	67	100
Stem height (cm)	224 d	229 c	242 a	237 b
LAI	2.6 c	3.0 b	3.7 a	3.2 b

Values within each row with same letters have not significant difference at 1% probability level.

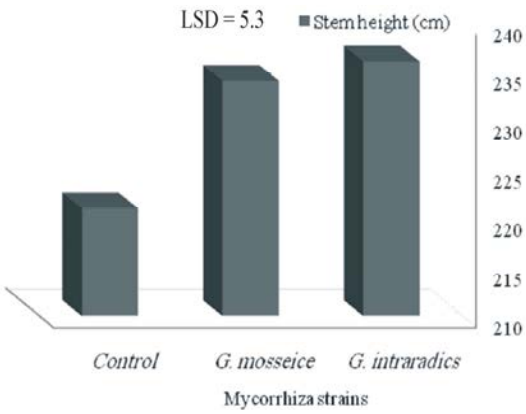

Fig. 1: Stem height of corn as affected by mycorrizal inoculation

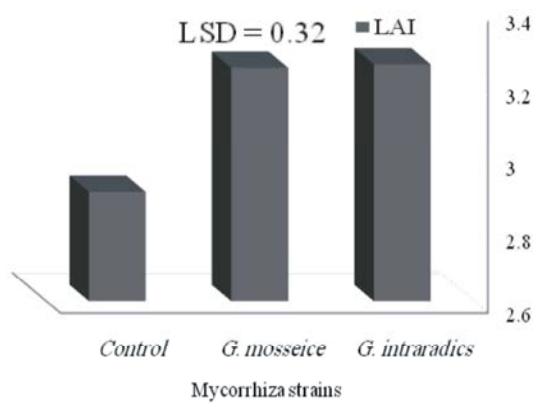

Fig. 2: LAI of corn as affected by mycorrizal inoculation.

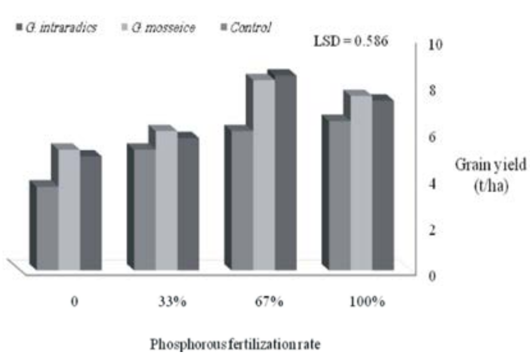

Fig. 3: Grain yield of corn as affected by mycorrhizal inoculation and phosphorous fertilization

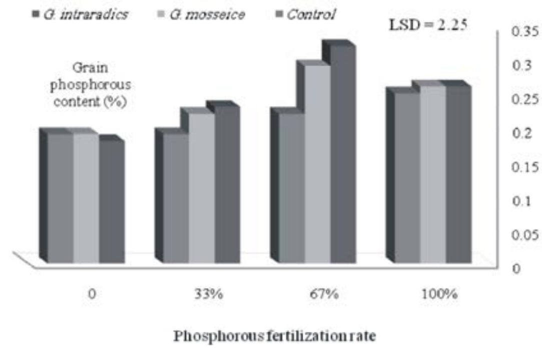

Fig. 4: Grain phosphorous content of corn as affected by mycorrhizal inoculation and fertilization

6.43 t ha^{-1}. Whereas, in those seeds inoculated with Mycorrhiza strains and fertilized with 67% recommended dose of phosphorous, yield improved 48% (Figure 3). Photosynthesis improvement in plants through Mycorrhiza symbiosis is mainly due to the increase in transporting of elements from soil to plants. Jahan *et al*. [9] emphasized on the positive effect of mycorrhizal inoculation of seeds on phosphorous, sulfur and zinc uptake by corn. One of the most important means to achieve the goals of sustainable agriculture is to extent the application of biological fertilizers. To reach this goal, it is necessary to moderate the use of chemical fertilizers and pesticides like through the time and in the mean time increase the soil organic matter content [14].

It seems that Mycorrhizal inoculation of corn seeds could reduce chemical phosphorous consumption, but increase phosphorous use efficiency and this will result in higher yield. This is in agreement with those reported by Subramanian *et al*. [15] on maize.

Grain Phosphorous Content: Interaction of Mycorrhiza strains and phosphorous fertilization on grain phosphorous content were significant at 1% probability level (Table 1). Higher grain phosphorous content was observed in treatments of 67% recommended dose of phosphorous plus inoculated seeds. But, increasing of grain phosphorous content in non-biofertilized seeds experiencd linear trend with increasing of phosphorous application rate (Figure 4). In this experiment, *G. mosseice* strain was more effective than *G. intraradics* on grain phosphorous content. The fungi are nourished by root exudates and in return bring great amounts of soil nutrients and moisture to their host plants [2, 3]. A variety of studies by Soleimanzadeh [16] on sunflower suggest that phosphorous uptake by plant root can be enhanced when they are infected by arbuscular mycorrhiza (AM) fungi.

CONCLUSION

Corn seeds biofertilization with both *Glomus intraradics* and *G. mosseice* Mycorrhiza strains may reduce in phosphorous fertilizer application rate in semi-arid regions and it can be resulting in reduction of fertilizers environmental hazards in sustainable maize production.

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