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Yield and nutritional changes in brinjal seedlings by arbuscular mycorrhizal inoculation under different P levels

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Abstract: A pot trial was conducted to study the response of brinjal (*Solanum melongenum L.*) cv. BARI Begun-8 to different phosphorus levels (0, 15, 30, 45 and 60 kg P ha^{-1}) using with and without vesicular-arbuscular mycorrhizal fungus, *Glomus fasciculatum* during the period from November, 2007 to January, 2008 in the net house of the Department of Agricultural Chemistry, Bangladesh Agricultural University (BAU), Mymensingh. At the seedling stage of brinjal, dry biomass and N, P, K, S, Ca, Mg, B, Zn, Mn, Cu and Na uptake differed significantly between inoculated and uninoculated control plants. Total biomass and all the above nutrient uptakes increased with increasing P level in uninoculated plants @ 30 kg P ha^{-1}, except for Zn and Cu which increased up to 15 kg P ha^{-1} and further higher levels of P, showed decreasing trend. The positive effect of AM (*G. fasciculatum*), inoculation and along with P application up to inoculated with AM when applied phosphorus @ 15 and 30 kg ha^{-1} and then after decreased with increasing P level above 30 kg P ha^{-1}, due to decreased percent root colonization and spore count at higher P levels. Thus the result suggested that mycorrhiza work better under low level of P.
Keywords: AM (*Glomus fasciculatum)*, macro and micro nutrients, brinjal.

Introduction

Mycorrhizae are an integral part of most plants in nature (Gianinazzi *et al*., 1992) and occur on 83% of dicotyledonous and 79% of monocotyledonous plants investigated (Wilcox, 1996). Infection of the root system of the plant by these mycorrhizae creates a symbiotic (beneficial) relationship between the plant and fungus. Arbuscular mycorrhizal fungi are ubiquitous in nature and colonize in most of the cultivated crops except members of Chenopodiaceae and Cruciferaceae. The principal function of Mycorrhiza is to increase the soil volume explored for nutrient uptake and to enhance the efficiency of nutrient absorption from the soil solution.Upon root infection and colonization, mycorrhizal fungi develop an external mycelium which is a bridge connecting the root with the surrounding soil (Toro *et al.* 1997). One of the most dramatic effects of infection by mycorrhizal fungi on the host plant is the increase in phosphorus (P) uptake (Koide, 1991) mainly due to the capacity of the mycorrhizal fungi to absorb phosphate from soil and transfer it to the host roots (Asimi, *et al.* 1980). In addition, mycorrhizal infection results in an increase in the uptake of copper, zinc, nickel, chloride and sulphate. Mycorrhizae also are known to reduce problems with pathogens which attack the roots of plants (Gianinazzi-Pearson & Gianinazzi, 1993). Availability of P is a serious problem, because it is fixed in the soil and lowers the utilization efficiency of added P fertilizers by plants. Soil microorganisms play a significant role in mobilizing P and increase the availability for plants. Therefore, mycorrhiza fungi can increase absorb of phosphorus by symbiosis with plant of root. This symbiosis can decrease application of phosphorus fertilizers in fields, without decrease quantity and quality yield of plant. Consequently, there has been longstanding interest in the manipulation of soil microorganisms to improve the P nutrition of plants, with the objective of increasing the overall efficiency of P-use in agricultural systems. Brinjal (*Solanum melongenum L.*) are the most important, popular, nutritious vegetable crops grown in Bangladesh which belongs to the family *Solanaceae*. For production of both quantitively and qualitively vegetables, healthy seedlings is one of the important factors affecting growth and yield of crops. Providing the best conditions to seedlings for growth and development is also important. Arbuscular mycorrhizal (AM) fungi might help to produce healthy and vigorous seedlings of vegetable (e.g. Brinjal, tomato etc), fruits and spices crops. Seedlings mortality by damping off disease of different vegetable crops is a major problem in Bangladesh. The AM fungi also might be helpful in controlling damping off disease of seedlings in the nursery. The fungi work better under low nutrient condition. Keeping these in view, the present investigation was undertaken with the following objectives: i) to evaluate the effect of AM and P on the total dry matter yield, nutrient contents and their uptake by brinjal seedlings and ii) to examine the efficiency of AM with various levels of P in raising brinjal seedlings.

Materials and Methods

The experiment was conducted in a net house in the BAU, Mymensingh. The experiment was laid out in a completely randomized design (CRD), with three replicates and ten treatments. Each treatment consisted of five P rates i.e., P_0 = 0, P_1 = 7.5, P_2 = 15.0, P_3 = 22.5, P_4 = 30.0 mg P kg^{-1} soil (from TSP) in combination with and without AM inoculation. Brinjal (*Solanum melongenum* L.) cv. BARI Begun-8 was used as plant material for the experiment. Seeds were collected from Horticultural Research Centre, BARI, Joydebpur. The inoculum of AM fungi (G. fasciculatum) was collected from trap crop of sorghum as infected root with soil which was preserved in the net house of Soil Science Division of the Bangaladesh Agricultural Reasearch Institute (BARI), Joydebpur, Gazipur. To conduct the experiment, (35 x 25 cm^2) polyethylene bags were collected and each polyethylene was poured with 3 kg finely ground mixer of soil and well decomposed cowdung with the ratio of 5:1. Urea, muriate of potash and gypsum were applied according to the Fertilizer Recommendation Guide (BARC, 2005). Half amount of urea and full doses of other fertilizers were applied one day before seeds sowing. The rest half amount of urea was applied at 20 days after sowing (DAS). Triple superphosphate was applied as per treatments of the experiment dividing into five doses (0, 15, 30, 45, and 60 kg ha^{-1}). Soil based AM inoculum containing about 200 spores (Measured by wet sieving and decanting method under stereomicroscope) and infected root pieces was used in the seed furrows of about 3 cm depth at the rate of 15 g kg^{-1} soil. Then 20 seeds were sown on 10 November 2007 in each furrow on AM inoculum and covered them by side soil. After sowing the seed, the soil was saturated with water. The seedlings were harvested at full maturity on 15 December 2007 after 35 days of germination. The harvesting was done by uprooting the whole plants. The soil adhering to the roots could be easily thrown away by jerking and washing with water. Weights of the plants with attached roots and without roots were taken immediately after harvesting and after oven dried to determine total dry matter yield. Total N, P, K, Ca, Mg, S and micro-nutrient contents, and their uptakes of whole plant by brinjal seedlings were determined by the method described by Jackson, 1973. The data were analysed using the appropriate statistical tools (Table 1).

Table 1: Initial values of soil parameters at the beginning of the trials in the planting seasons

Constituents	Charecteristic
Textural class	Silty loam
Sand (%)	17.55
Silt (%)	62.83
Clay (%)	20.85
pH	6.8
CEC (%)	8.4
Total N (%)	0.11
Organic carbon (%)	0.68
Available P (µg g^{-1} soil)	11.98

Results and Discussion

Dry matter yield

There was a highly significant response of mycorrhizal inoculant on total dry matter yield in brinjal cv. BARI begun-8 seedlings (Fig. 1). Inoculated plants recorded significantly higher dry matter yield over uninoculated plant. Inoculated plant gave the higher dry matter yield (1337 mg $seedling^{-1}$) whereas uninoculated plant gave the lower dry matter yield (720 mg $seedling^{-1}$). Application of P @ 15 kg ha^{-1} produced the highest total dry matter yield (1622 mg $seedling^{-1}$), which was higher over all other P levels but identical to P_2. Treatments P_0, P_3 and P_4 were statistically identical. The lowest total dry matter yield (1393 mg $seedling^{-1}$) was observed in control treatment (P_0). The combination of phosphorus x AM inoculant application on total dry matter yield was statistically significant.

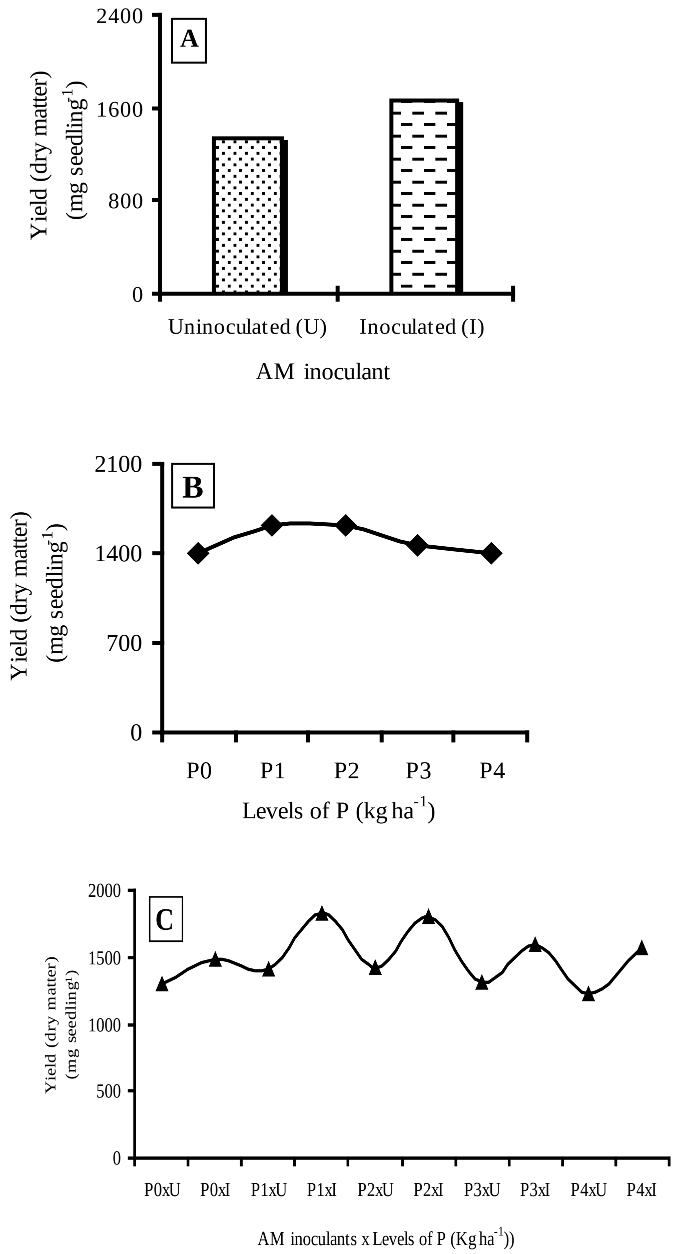

Fig. 1 Effect of AM inoculation (A), P levels (B) and interaction of AM and P levels (B) on dry matter yield of brinjal seedlings

AM inoculant when applied with P @ 15 kg ha^{-1} produced the highest dry matter yield (1830 mg $seedling^{-1}$). The lowest dry matter yield (1230 mg $seedling^{-1}$) was observed in P_4 x U treatments. Rahman *et al.* (2006) studied the interaction of arbuscular mycorrhizal fungus and phosphorus under different soil conditions in Bangladesh. They reported that inoculation with AM plus P increased dry matter yield in some crops under observation.

Macro nutrient contents and their uptake

Inoculation of arbuscular mycorrhiza increased the N, P, K, S, Ca and Mg contents and their uptakes by brinjal seedlings (Table 1). Inoculated treatment showed higher N content (0.74%) and uptake (12.26 mg seedling^{-1}), P content (0.41%) and uptake (7.27 mg seedling^{-1}), K content (1.18%) and uptake (20.90 mg seedling^{-1}), S content (0.19%) and uptake (3.46 mg seedling^{-1}), Ca content (0.74%) and uptake (12.31 mg seedling^{-1}) and Mg content (0.76%) and uptake (12.60 mg seedling^{-1}) and the uninoculated treatment recorded the lowest N content (0.64%) and uptake (8.49 mg seedling^{-1}), P content (0.38%) and uptake (5.11 mg seedling^{-1}), K content (1.14%) and uptake (15.2 mg seedling^{-1}), S content (0.18%) and uptake (2.44 mg seedling^{-1}), Ca content (0.67%) and uptake (8.97 mg seedling^{-1}) and Mg content (0.69%) and uptake (9.26 mg seedling^{-1}), respectively. All the above nutrients were significantly increased but only except for K uptake. Influence of arbuscular mycorrhiza and phosphate rock on uptake of major nutrients by *Acacia mangium* seedlings were investigated by Satter *et al.*, 2006 to know the uptake of major nutrients by seedlings and repotted that N, P, Ca, Mg concentrations were significantly increased by pre transplant VAMF colonization in soils.

Phosphorus fertilization increased different nutrients and their uptakes positively up to certain level. Results presented in Table 2 showed that % N content and N uptake by brinjal seedlings was significantly varied and progressively increased by P application as compared with control treatment. The highest N content (0.75%) and N uptake (12.21 mg seedling^{-1}) was noted in P_2 treatment. The lowest N content (0.64%) and N uptake (8.91 mg seedling^{-1}) was found in P_0 treatment. Among the treatments, the highest P content (0.44%) and uptake (21.38 mg seedling^{-1}) was observed at P_2 and $P_{1,}$ respectively which were statistically identical. The lowest P content (0.34%) and uptake (15.54 mg seedling^{-1}) was recorded in control treatment (P_0)$_.$ Potassium content and uptake differed significantly due to different levels of P application. The highest K content (1.18%) and uptake (21.38 mg seedling^{-1}) and S content (0.21%) and uptake (3.74 mg seedling^{-1}) was obtained when the crop was fertilized with 15 kg P ha^{-1} which was statistically similar to all the levels except P_0 for K content but identical to P_2 for K uptake. The lowest K content (1.11%) and uptake (15.54 mg seedling^{-1}) was found in control. The lowest S content and uptake were recorded in P_4 which were 0.18% and 2.48 mg seedling^{-1}, respectively. The treatment P_2 accumulated both maximum Ca uptake (11.71 mg seedling^{-1}) and Mg content (0.76%) and uptake (12.35 mg seedling^{-1}) which was statistically identical with 15 and 45 kg P ha^{-1} for Ca uptake and P_{15} for Mg uptake. The minimum accumulation of Ca content (0.65%) and uptake (9.06 mg seedling^{-1}) and Mg content (0.67%) and uptake (9.36 mg seedling^{-1}) was obtained from P_0 (Table 2).

From Table 3, it was found that inoculation of AM and P interaction was statistically insignificant for most of the contents except P but significantly varied for all the uptakes. Application of P_2 x I treatment showed the highest N content (0.80%) and N uptake (14.43 mg seedling^{-1}). The lowest N content (0.59%) and N uptake (7.38 mg seedling^{-1}) was recorded in treatment P_0 x U and P_4 x U, respectively (Table 3). In all the AM and P combinations, increasing level of P increased both N content and uptake in brinjal seedlings but the increasing level of P after P_2 had a decreasing effect of N content and uptake. The highest P content (0.50%) and uptake (26.56 mg seedling^{-1}) was found in treatment P_2 x I and P_1 x I, respectively. This result of P content was statistically identical with P_1 x I treatment. In contrast, the lowest P content (0.33%) and uptake (14.00 mg seedling^{-1}) was found in treatment P_0 x U and P_4 x U. From this result, it was evident that both mycorrhizal inoculation and P level accelerated the accumulation of P up to a certain level and there after decreased in brinjal seedlings. These findings also confirmed the reports of Chitdeshwan *et al.* (1998), who studied the effect of different levels of phosphorous and VA mycorrhiza. Soil and plant P level after harvest was increased by mycorrhizae inoculation. The highest K content (1.21%) and uptake (26.56 mg seedling^{-1}) and S content (0.22%) and uptake (4.75 mg seedling^{-1}) was recorded when mycorrhizal inoculant was applied with P_1 level, which was superior to all.

The control treatment, P_0 x U gave the lowest K content (1.09%) and P_4 x U gave the lowest uptake (14.00 mg seedling^{-1}) whereas the lowest S content (0.17%) and uptake (2.13 mg seedling^{-1}) was in P_4 x U treatment (Table 3). The highest Ca content (0.81%) and uptake (13.59 mg seedling^{-1}) was achieved from P_3 x I and P_2 x I, respectively and Mg content (0.80%) and uptake (14.57 mg seedling-1) was achieved from P_{30} x I treatment. The lowest Ca content (0.63%) and uptake (8.16 mg seedling^{-1}) and Mg content (0.65%) and uptake (8.43 mg seedling^{-1}) was found from P_0 x U treatment combination. Influence of arbuscular mycorrhiza and phosphate rock on uptake of major nutrients by *Acacia mangium* seedlings were investigated by Satter et al. (2006) to know the uptake of major nutrients by seedlings. The plant samples were analyzed and showed that for Ca content and uptake was significantly influenced by AM inoculation.

Micro nutrient contents and their uptake

Boron, Zn, Cu, Mn and Na contents and their uptake by brinjal seedlings significantly influenced by the inoculation of arbuscular mycorrhizal fungi (Table 4). Among two treatments, higher Mn content (86.25 µg g^{-1}) and uptake (143.75 µg seedling^{-1}) was observed in inoculated treatment and the lowest Mn content (78.48 µg g^{-1}) and uptake (105.24 µg seedling^{-1}) was found in uninoculated treatment. Inoculated plant gave higher B content (35.02 µg g^{-1}) and uptake (58.94 µg seedling^{-1}) whereas uninoculated plant gave lower content (29.26 µg g^{-1}) and uptake (39.32 µg seedling^{-1}). The Zn content (97.03µg g^{-1}) and uptake (161.76 µg seedling^{-1})

Table 1 Effect of *G. fasciculatum* on macronutrient contents and their uptake by brinjal seedlings

G. fasciculatum	Nitrogen		Phosphorus		Potassium		Calcium		Magnesium		Sulphur	
	Content (%)	Uptake (mg seed-ling-1)	Conten t (%)	Uptake (mg seed-ling-1)	Content (%)	Uptake (mg seed-ling-1)	Content (%)	Uptake (mg seed-ling-1)	Conten t (%)	Uptake (mg seed-ling-1)	Content (%)	Uptake (mg seed-ling-1)
Uninoculated	0.64	8.49	0.38	5.11	1.14	15.20	0.67	8.97	0.69	9.26	0.18	2.44
Inoculated	0.74	12.26	0.41	7.27	1.18	20.90	0.74	12.31	0.76	12.60	0.19	3.46
LSD (0.05)	0.03	0.55	0.03	0.22	0.02	0.76	0.03	0.55	0.03	0.67	0.01	0.19

Table 2 Effect of phosphorus levels on macronutrient contents and their uptake by brinjal seedlings

P levels (kg ha^{-1})	Nitrogen		Phosphorus		Potassium		Calcium		Magnesium		Sulphur	
	Content (%)	Uptake (mg seed-$ling^{-1}$)	Content (%)	Uptake (mg seed - ling-1)	Content (%)	Uptake (mg seed-$ling^{-1}$)	Content (%)	Uptake (mg seed-$ling^{-1}$)	Content (%)	Uptake (mg seed-$ling^{-1}$)	Content (%)	Uptake (mg seed-$ling^{-1}$)
P_0	0.64	8.91	0.34	15.54	1.11	15.54	0.65	9.07	0.67	9.36	0.19	2.58
P_1	0.71	11.37	0.40	21.38	1.18	21.38	0.69	11.32	0.72	11.68	0.21	3.74
P_2	0.75	12.21	0.44	20.08	1.17	20.08	0.72	11.71	0.76	12.35	0.19	3.31
P_3	0.70	10.20	0.39	17.08	1.17	17.08	0.76	11.14	0.76	11.04	0.18	2.65
P_4	0.65	9.20	0.39	16.18	1.16	16.18	0.71	9.95	0.73	10.23	0.18	2.48
LSD (0.05)	0.04	0.87	0.04	1.21	0.04	1.21	0.04	0.86	0.04	1.06	0.01	0.31

Table 3 Interaction effect of *G. fasciculatum* and phosphorus on macronutrient contents and their uptake by brinjal seedlings

P x AM Interaction	Nitrogen		Phosphorus		Potassium		Calcium		Magnesium		Sulphur	
	Content (%)	Uptake (mg seed-$ling^{-1}$)	Conten t (%)	Uptake (mg seed-$ling^{-1}$)	Conten t (%)	Uptake (mg seed-$ling^{-1}$)	Content (%)	Uptake (mg seed-$ling^{-1}$)	Content (%)	Uptake (mg seed-$ling^{-1}$)	Content (%)	Uptake (mg seed-$ling^{-1}$)
P_0 x U	0.59	7.79	0.33	14.08	1.09	14.08	0.63	8.16	0.65	8.43	0.17	2.38
P_0 x I	0.66	10.00	0.35	17.01	1.14	17.01	0.67	9.97	0.69	10.28	0.18	2.78
P_1 x U	0.64	9.04	0.42	16.19	1.15	16.19	0.66	9.26	0.68	9.60	0.19	2.73
P_1 x I	0.75	13.69	0.46	26.56	1.21	26.56	0.73	13.37	0.75	13.75	0.22	4.75
P_2 x U	0.70	9.98	0.39	16.40	1.15	16.40	0.69	9.83	0.71	10.13	0.19	2.66
P_2 x I	0.80	14.43	0.50	23.76	1.18	23.76	0.75	13.59	0.80	14.57	0.20	3.95
P_3 x U	0.65	8.25	0.38	15.32	1.16	15.32	0.71	9.34	0.73	9.62	0.18	2.32
P_3 x I	0.76	12.14	0.40	18.83	1.18	18.83	0.81	12.94	0.78	12.46	0.18	2.98
P_4 x U	0.60	7.38	0.37	14.00	1.16	14.00	0.67	8.25	0.69	8.50	0.17	2.13
P_4 x I	0.70	11.02	0.39	18.36	1.17	18.36	0.74	11.65	0.76	11.95	0.18	2.83
LSD (0.05)	0.05	1.23	0.05	1.70	0.05	1.70	0.05	1.22	0.05	1.50	0.02	0.43
CV (%)	4.4	7.0	6.0	5.5	3.2	5.5	4.6	6.7	4.2	8.0	7.5	8.6

Table 4 Effect of *G. fasciculatum* on micro nutrient contents and their uptake by brinjal seedlings

G. fasciculatum	**Manganese**		**Zinc**		**Boron**		**Copper**		**Sodium**	
	Content (μg g^{-1})	Uptake (μg seed-ling^{-1})	Content (μg g^{-1})	Uptake (μg seed-ling^{-1})	Content (μg g^{-1})	Uptake (μg seed-ling^{-1})	Content (μg g^{-1})	Uptake (μg seed-ling^{-1})	Content (%)	Uptake (mg seed-ling^{-1})
Uninoculated	78.48	105.24	88.83	119.07	29.26	39.32	22.17	30.19	0.36	4.87
Inoculated	86.25	143.75	97.03	161.76	35.02	58.94	31.53	52.94	0.38	6.79
LSD (0.05)	2.82	7.63	3.09	9.12	3.46	6.61	2.64	4.95	0.01	0.24

Table 5 Effect of phosphorus levels on micro nutrient contents and their uptake by brinjal seedlings

P levels (Kg ha^{-1})	**Manganese**		**Zinc**		**Boron**		**Copper**		**Sodium**	
	Content (μg g^{-1})	Uptake (μg seed-ling^{-1})	Content (μg g^{-1})	Uptake (μg seed-ling^{-1})	Content (μg g^{-1})	Uptake (μg seed-ling^{-1})	Content (μg g^{-1})	Uptake (μg seed-ling^{-1})	Content (%)	Uptake (mg seedling^{-1})
P_0	75.40	109.42	93.96	131.38	25.44	39.85	28.51	39.98	0.37	5.16
P_1	83.41	136.11	100.87	165.19	32.69	53.75	34.16	56.56	0.38	6.88
P_2	90.47	147.35	95.69	155.48	39.81	64.32	28.04	46.50	0.38	6.56
P_3	82.31	122.02	90.37	132.13	33.53	49.37	24.55	37.49	0.37	5.42
P_4	78.25	107.57	83.79	117.91	29.23	38.37	19.00	27.29	0.36	5.13
LSD (0.05)	4.46	12.06	4.89	14.42	5.47	10.46	4.18	7.83	0.01	0.10

Table 6 Interaction effect of *G. fasciculatum* and phosphorus on micro nutrient contents and their uptake by brinjal cv. seedlings

P X AM Interaction	Manganese		Zinc		Boron		Copper		Sodium	
	Content (μg g^{-1})	Uptake (μg seed-ling^{-1})	Content (μg g^{-1})	Uptake (μg seed-ling^{-1})	Content (μg g^{-1})	Uptake (μg seed-ling^{-1})	Content (μg g^{-1})	Uptake (μg seed-ling^{-1})	Content (%)	Uptake (mg seed-ling^{-1})
P_0 x U	76.39	99.13	90.29	117.14	23.67	33.32	25.61	33.25	0.36	4.75
P_0 x I	80.41	119.71	97.63	145.62	31.21	46.37	31.4	46.70	0.37	5.56
P_1 x U	79.26	111.87	94.29	133.41	29.49	41.53	28.52	40.09	0.36	5.13
P_1 x I	87.56	160.35	107.45	196.97	36.89	65.96	39.79	73.04	0.39	8.64
P_2 x U	85.66	122.33	91.63	130.61	34.72	49.59	22.43	32.06	0.37	5.23
P_2 x I	95.28	172.37	99.74	180.35	42.89	79.05	33.65	60.94	0.39	7.90
P_3 x U	78.99	104.09	87.51	115.33	30.25	39.80	18.96	26.75	0.37	4.83
P_3 x I	87.63	139.96	93.22	148.93	36.81	58.94	30.14	48.25	0.38	6.01
P_4 x U	72.12	88.80	80.43	98.88	25.19	32.33	15.33	18.81	0.36	4.43
P_4 x I	80.37	126.3b	87.15	136.93	28.27	44.40	22.67	35.78	0.37	5.83
LSD (0.05)	6.301	17.06	6.92	20.40	7.74	14.79	5.908	11.07	0.02	0.54
CV (%)	4.49	8.04	4.4	8.5	14.13	17.67	12.92	15.64	3.85	5.40

was higher when inoculated with AM and content (88.83 µg g^{-1}) and uptake (119.07 µg $seedling^{-1}$) was also lower without inoculation of AM. It was also noted that Zn content and uptake increased remarkably with the inoculation of AM. Similar results were reported by Seres *et al.* (2006), who reported that in the presence of AMF, the Zn content of the plant shoots and roots was significantly higher than without AMF. Inoculation of AM produced the highest Cu content (31.53 µg g^{-1}) and uptake (52.94 µg $seedling^{-1}$); where as uninoculated treatment produced the lowest content (22.17 µg g^{-1}) and uptake (30.19 µg $seedling^{-1}$). Sodium content and uptake showed significant effect by inoculation with AM in brinjal seedlings. Data presented in Table 4 showed that inoculated treatment showed higher Na content (0.38%) and uptake (6.79 mg $seedling^{-1}$) and the uninoculated treatment recorded lower Na content (0.36%) and uptake (4.87 mg $seedling^{-1}$), respectively.

Application of different levels of P exerted significant variation in B, Zn, Cu, Mn, Na contents and their uptake by brinjal seedlings (Table.5). It was recorded that the B content (39.81 µg g^{-1}) and uptake (64.32 µg $seedling^{-1}$) was the highest at P_{30}. The lowest B content (25.44 µg g^{-1}) and uptake (38.37 µg seedling^{-}1) was at P_0 and P_{60} treatments, respectively. The highest Zn content (100.87 µg g^{-1}) and uptake (165.19 µg $seedling^{-1}$) was recorded due to the application of P @ 15 kg ha^{-1} which was superior to all for Zn content but identical to P_2 for Zn uptake. The lowest number Zn content (83.79 µg g^{-1}) and uptake (117.91 µg $seedling^{-1}$) was recorded in P_4 level. From the above results, it was clear that the interaction between P and Zn in brinjal seedlings was antagonistic. The highest Mn content (90.47 µg g^{-1}) and uptake (147.35 µg $seedling^{-1}$) was obtained when the crop was fertilized with 30 kg P ha^{-1} which was statistically similar to 15 kg P ha^{-1} on uptake not for content. The lowest Mn content (75.40 µg g^{-1}) and uptake (107.57 µg $seedling^{-1}$) was found from 0 and 60 kg P ha^{-1}, respectively. The highest Cu content (34.16 µg g^{-1}) and uptake (56.56 µg $seedling^{-1}$) was observed when the crop was fertilized with 15 kg P ha^{-1}. On the other hand, the lowest content (19.00 µg g^{-1}) and uptake (27.29 µg $seedling^{-1}$) was recorded from the P_4 treatment. It was also mentioned that control treatment was better than higher levels of P application (P_3) for Ca content and uptake, which interacted antagonistically. Application of different levels of P had significant effect on Na uptake and non significant on content of brinjal seedlings Among the treatments, the highest Na content (0.38%) and uptake (6.88 mg $seedling^{-1}$) was observed in P_2 treatment which was superior to all other treatments for uptake. The lowest Na content (0.36%) and uptake (5.13 mg $seedling^{-1}$) was found in P_4 treatment.

The combination of AM and different levels of P significantly influenced B , Zn, Cu, Mn, Na uptake by brinjal seedlings (Table 6). On the other hand, B, Zn, Cu, Mn, and Na content were not influenced significantly. The highest B content (42.89 µg g^{-1}) and uptake (79.05 µg $seedling^{-1}$) was recorded in P_2 x I treatment combination, which was statistically similar with P_1 x I treatment. The minimum B content (23.67 µg g^{-1}) and uptake (32.33 µg $seedling^{-1}$) was observed in P_0 x U and P_4 x U treatment combination respectively. The treatment P_1 x I contained maximum Zn content (107.45 µg g^{-1}) and uptake (196.96 µg $seedling^{-1}$), Cu content (39.79 µg g^{-1}) and uptake (73.04 µg $seedling^{-1}$) and Mn content (95.28 µg g^{-1}) and uptake (160.35 µg $seedling^{-1}$) which was better than all other treatments except P_2 x I. The treatment P_4 x U contained minimum Zn content (80.43 µg g^{-1}) and uptake (98.88 µg $seedling^{-1}$), whereas the control treatment was superior to the highest two treatment combination. It was revealed from the results that AM inoculation with P fertilization at different levels Zn content and uptake increased with low phosphorus level in brinjal seedlings. The lowest Cu content (15.33 µg g^{-1}) and uptake (18.81 µg $seedling^{-1}$) was found in control P_4 x U treatment combination. From this result, it was evident that Cu content and uptake in brinjal seedlings decreased with increasing level of P.

The lowest Mn content (76.39 µg g^{-1}) and uptake (80.88 µg $seedling^{-1}$) was obtained in treatment combination from P_0 x U and P_4 x U, respectively. The highest Na content (0.39%) and uptake (8.64 mg $seedling^{-1}$) was found when the crop was fertilized with 15 and 30 kg P and inoculated with AM, and the lowest Na content (0.36%) was from P_0 x U, P_1 x U, P_4 x U and uptake (4.43 mg $seedling^{-1}$) was from P_4 x U.

The positive effect of mycorrhizal inoculation and along with P application up to inoculated with AM when applied phosphorus @ 15 and 30 kg ha^{-1} and then after decreased with increasing P level above 30 kg P ha^{-1}. The study ventilated that AM use as a biofertilizer for production of brinjal seedlings reduced 50% phosphatic fertilizer as recommended dose. Further studies may be under taken to explore the possibility of more effective for tomato and brinjal up to yield as well as for other crops to minimize the use of costly phosphatic fertilizer in the country. Finally repeated field trials also necessary to use them as biophosphorus fertilizer.

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