J. Agrofor. Environ. 4 (2): 41-44, 2010 ISSN 1995-6983

Influence of arbuscular mycorrhiza and different levels of phosphorus on yield attributes, yield and micronutrient contents in chilli cv. BARI morich-1

S. Sultana, B.K. Saha, M.A.H. Chowdhury and M.A.H. Bhuiyan
Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh-2202

Abstract: A pot experiment was conducted to investigate the influence of arbuscular mycorrhiza (AM) and different levels of phosphorus (P) on yield attributes, yield and micronutrient contents and their uptake by chilli. Mycorrhizal inoculation significantly influenced total fruits plant^{-1}, fresh fruit weight plant^{-1}, seeds fruit^{-1}, B, Zn and Cu contents and their uptake except dry fruit weight plant^{-1} and fruit volume. Like mycorrhiza, phosphorus fertilization also significantly influenced most of the parameters studied. The highest values of the parameters were obtained from the treatment fertilized with 40 kg P ha^{-1} except B in shoot and root which was highest in P_{60}. AM inoculation in combination with 40 kg P ha^{-1} produced the highest number of fruit, fresh and dry fruit weight plant^{-1}, seeds fruit^{-1} and micronutrient contents and their uptake. The overall result suggests that mycorrhizal inoculation with 40 kg P ha^{-1} can be used for better growth and higher yield of chilli.
Key words: Arbuscular mycorrhiza, yield, micronutrient contents, AM and P interection.

Introduction

Mycorrhizal fungi form mutualistic associations with the roots of land plants, providing the plant with phosphorus and other nutrients in exchange for photosynthate (Smith and Read, 1997). Mycorrhizal association is of particularly significant because it markedly increase the availability of several essential nutrients to plants, including P, K, Zn, Cu, Ca, Mg, Mn and Fe, especially from infertile soils. Plants are benefited by AMF in many ways. The major benefit of AMF association is: increase of mobile nutrients particularly P and micronutrients (Douds and Millner, 1999). Systematic research on the effect of arbuscular mycorrhizal fungi with different agricultural crops, sand dune plants and plantation crops has been carried out in Bangladesh for last few years. However, scientific information on the occurrence of AM fungi in association with different agricultural and forest crops of Bangladesh is still scarce. Phosphorus is one of the essential mineral macronutrients which is required for maximizing the yield of crops. Most agricultural soils contain large reserves of phosphorus, a considerable part of which accumulate as a consequence of regular applications of P fertilizers (Richardson, 1994). Chilli is a valuable spice and also an important cash crop in Bangladesh. About 170041 hectares of land of Bangladesh is under chilli cultivation in both rabi and kharif seasons and the production is about 137,000 M ton (BBS, 2004). Though the area and production have been raised but per unit yield of chilli is very low. It seems, therefore, that there is a bright prospect of using AM as biofertilizer in chilli cultivation in Bangladesh.

Materials and Methods

The experiments were conducted in the net house in the BAU, Mymensingh. The experiment was laid out in a completely randomized design (CRD) with four replications and ten treatments. The treatment consisted of five P rates *i.e.* P_0, P_{20}, P_{40}, P_{60} and P_{80} with and without AM inoculation. Chilli (*Capsicum frutescens* L.) cv. BARI morich-1 was used as plant material for the experiment. The inoculum of AM fungi was collected from the trap crop of sorghum as infected root with soil which was preserved in the net house of Soil Science Division of the BARI, Joydebpur, Gazipur. Nitrogen as urea, potassium as muriate of potash, sulphur as gypsum, boron as boric acid and zinc as zinc sulphate were applied according to the Fertilizer Recommendation Guide (BARC, 2005). Urea was applied in three equal splits. One third amount of urea and full doses of other fertilizers were applied one day before seeds sowing. The rest two thirds of urea were applied at 100 days after sowing (DAS) and 140 DAS respectively. Triple superphosphate was applied as per treatment. Fifty gram inoculum was applied per earthen pot. A layer of AM inoculum was first placed in each pot filled with sun dried soil and was covered with a thin soil layer of 2 cm in which seeds were sown. Twenty seeds of chilli treated with sodium hypochlorite for surface sterilization were sown in each pot. Pots were irrigated upto saturation to allow the soil and inoculums to settle down in the pots. Intercultural operations were done as and when necessary. The harvesting was done by uprooting the whole plants. Ca, Mg contents and their uptake by chilli plant were analyzed following the standard methods (Page *et al*., 1982). P, K and S contents and their uptake by chilli plants were determined by the method described by Jackson (1973), Ghosh *et al*. (1983), Wolf (1982), respectively. Total nitrogen was determined by Semi- Micro Kjeldahl method (Page *et al.*, 1982). Analysis of variance was done with the help of computer package MSTATC developed by Russel (1986) and the mean differences of the treatments were adjudged by LSD test.

Results and Discussion

Effect of AM inoculation, different levels of P and their interactions on yield attributes and yield of chilli plant

Total fruits plant^{-1}: The effects of mycorrhizal inoculum on total fruits plant^{-1} were significant in chilli plant (Table 1). The AM inoculated plants produced higher fruits plant^{-1} (106 plant^{-1}), while uninoculated plants produced lower fruits plant^{-1} (95 plant^{-1}). This might be due to positive response of AM on chilli for higher production. The total fruits plant^{-1} differed significantly due to different levels of P application (Table 2). The highest total fruits plant^{-1} (116 plant^{-1}) were recorded with P_{60} level which differed from all other P levels. The lowest total fruits plant^{-1} (92 plant^{-1}) were recorded with P_0 level. The result indicated that upto P_{60} level total number of fruits increased. Masud *et al.* (2008) conducted an experiment with 6 levels of fertilizers and observed that the highest fresh fruit weight (482 plant^{-1}) was observed in the 75% soil test based fertilizer plus 10 ton poultry manure ha^{-1} and the lowest fresh fruit weight (241 plant^{-1}) was found in control treatment. The treatment combination of AM inoculation and levels of P varied significantly in total fruits plant^{-1} (Table 3). The highest number of fruits plant^{-1} (119 plant^{-1}) were recorded from the treatment combinations of P_{60} × I and the control treatment P_0 × U gave the lowest total fruits plant^{-1} (86 plant^{-1}).

Table 1. Effect of arbuscular mycorrhiza (AM) on yield attributes and yield of chilli cv. BARI morich-1

Effect of AM	Total fruits plant^{-1}	Fresh fruit weight plant^{-1} (g)	Dry fruit weight plant^{-1} (g)	Seeds fruit^{-1}
Without AM	95b	282.3b	47.5	59.7b
With AM	106a	294.2a	49.0	64.8a
SE (±)	1.40	10.03	3.19	1.29
Level of sig.	**	**	NS	**

In a column, the figure (s) having different letter are significantly different at 1% level of probability by DMRT

Table 2. Effect of different levels of phosphorus (P) on yield attributes and yield of chilli cv. BARI morich-1

Effect of P (kg ha^{-1})	Total fruits plant^{-1}	Fresh fruit wt. plant^{-1} (g)	Dry fruit wt. plant^{-1}(g)	Seeds fruit^{-1}
P_0	92d	244.0b	41.3	61.9
P_{20}	97c	269.0b	45.6	62.8
P_{40}	108b	335.5a	50.3	64.8
P_{60}	116a	332.1a	61.6	60.6
P_{80}	92d	260.8b	42.2	60.1
SE (±)	1.40	18.27	5.05	2.04
Level of sig.	**	**	NS	NS

In a column, the figure(s) having same letter are not significantly different at 1% level of probability by DMRT.

Table 3. Interaction effect of arbuscular mycorrhiza (AM) and phosphorus on yield attributes and yield of chilli cv. BARI morich-1

Interaction effect (AM × P)	Total fruits plant^{-1}	Fresh fruit wt. plant^{-1} (g)	Dry fruit wt. plant^{-1} (g)	Seeds fruit^{-1}
P_0 × U	86f	222.2	41.7	61.5abc
P_0 × I	97cd	265.8	42.4	65.3abc
P_{20} × U	87ef	260.9	47.1	62.5abc
P_{20} × I	108b	277.0	44.1	67.0ab
P_{40} × U	99c	322.6	47.2	63.5abc
P_{40} × I	118a	348.3	53.5	68.0a
P_{60} × U	112b	317.3	60.1	63.8abc
P_{60} × I	119a	346.8	63.0	62.5abc
P_{80}× U	93d	288.3	42.8	61.0bc
P_{80} × I	92de	233.3	40.2	59.3c
SE (±)	2.53	23.99	7.14	2.60
Level of sig.	**	NS	NS	**

U= Non-inoculated, I= Inoculated, AM=Arbuscular Mycorrhiza

In a column, the figure(s) having same letter are not significantly different at 1% level of probability by DMRT.

Table 4. Effect of arbuscular mycorrhiza (AM) on micronutrient contents in shoot, root and fruit of chilli cv. BARI morich-1

Effect of AM	Zinc (μg g^{-1})		Copper (μg g^{-1})		Boron (μg g^{-1})	
	Shoot and root	Fruit	Shoot and root	Fruit	Shoot and root	Fruit
Without AM	49.10b	33.68b	6.63b	6.06	15.14b	12.64b
With AM	52.45a	36.79a	7.21a	6.12	17.22a	14.47a
SE (±)	0.882	0.813	0.032	0.028	0.132	0.083
Level of sig.	**	**	**	NS	**	**

In a column, the figure(s) having different letter are significantly different at 1% level of probability by DMRT

Fresh fruit weight plant^{-1}: Fresh fruit weight of chilli plant varied significantly by the effect of inoculation of arbuscular mycorrhizal fungi (Table 1). The variation was significantly higher (294.2 g) in AM inoculation than the uninoculated plant (282.3 g). The fresh fruit weight of chilli plant varied significantly with different P levels (Table 2). The treatment P_{40} produced the maximum fresh fruit weight (335.5 g) which was identical to P_{60} and minimum (244.02 g) was found from the control treatment. The result presented in Table 3 showed that fruit weight of chilli plant cv. BARI morich-1 was not significantly affected by the interaction of AM inoculation and levels of P. Shil *et al.* (2008) also recorded similar increase of fruit weight of chilli.

Dry fruit weight plant^{-1}: Inoculation of arbuscular mycorrhiza had no significant effect on dry fruit weight of chilli plant (Table 1). Dry fruit weight of chilli plant was also not statistically significant by phosphorus application

(Table 2). The interaction effect of phosphorus and AM on dry fruit weight was not significant (Table 3). The highest dry fruit weight (63.0 g) was recorded when mycorrhizal inoculant was applied with P_{60} level, which was numerically the best of all. The treatment $P_{80} \times$ I produced the lowest dry fruit weight (40.2 g).

Table 5. Effect of different levels of phosphorus on micronutrient contents in shoot, root and fruit of chilli cv. BARI morich-1

Effect of P	Zinc (µg g^{-1})		Copper (µg g^{-1})		Boron (µg g^{-1})	
(kg ha^{-1})	Shoot and root	Fruit	Shoot and root	Fruit	Shoot and root	Fruit
P_0	45.13cd	31.60bc	6.36d	6.09b	8.98d	8.84e
P_{20}	57.25b	34.68b	7.16b	5.88c	14.61c	15.31b
P_{40}	61.88a	50.63a	7.43a	6.89a	18.17b	19.43a
P_{60}	48.75c	30.75c	6.95c	6.15b	19.51a	14.09c
P_{80}	40.88d	28.50c	6.70e	5.20d	18.61b	10.11d
SE (±)	1.394	1.29	0.050	0.044	0.209	0.131
Level of sig.	**	**	**	**	**	**

In a column, the figure(s) having same letter are not significantly different at 1% level of probability by DMRT.

Table 6. Interaction effect of arbuscular mycorrhiza (AM) and phosphorus on micro nutrientcontents in shoot, root and fruit of chilli cv. BARI morich-1

Interaction effect	Zinc (µg g^{-1})		Copper (µg g^{-1})		Boron (µg g^{-1})	
(AM × P)	Shoot and root	Fruit	Shoot and root	Fruit	Shoot and root	Fruit
$P_0 \times$ U	36.00d	30.53cde	6.33e	6.12c	7.15	8.38h
$P_0 \times$ I	44.25c	32.68cd	6.40e	6.06c	10.80	9.31g
$P_{20} \times$ U	51.00b	34.60c	6.79d	6.14c	13.73	10.53f
$P_{20} \times$ I	63.50a	34.75c	7.54b	5.61d	15.50	20.10b
$P_{40} \times$ U	61.00a	43.75b	6.94cd	6.73b	16.75	17.38c
$P_{40} \times$ I	62.75a	57.50a	7.91a	7.04a	21.60	21.48a
$P_{60} \times$ U	53.50b	33.00cd	6.75d	6.09c	19.13	14.23d
$P_{60} \times$ I	44.00c	28.50de	7.14c	6.22c	19.90	13.95d
$P_{80} \times$ U	43.00b	26.50e	6.33e	5.25e	18.93	12.70e
$P_{80} \times$ I	47.75bc	30.50cde	6.45e	5.16e	18.30	7.53i
SE (±)	1.971	1.82	0.071	0.063	0.295	0.186
Level of sig.	**	**	**	**	NS	**

U= Non-inoculated, I= Inoculated, AM=Arbuscular Mycorrhiza
In a column, the figure(s) having same letter are not significantly different at 1% level of probability by DMRT

Seeds fruit^{-1}: Inoculation of arbuscular mycorrhiza had significant effect on seeds fruit^{-1} in chilli plant (Table 1). The highest number of seeds (64.8) were recorded with AM inoculation and the lowest number of seeds (59.70) were recorded without AM inoculation. Phosphorus had no significant effect on seeds fruit^{-1} (Table 2). The interaction effect of P × AM on seeds fruit^{-1} was not significant (Table 3).

Effect of AM inoculation, different levels of P and their interaction on micronutrient contents of chilli plant

Zinc content in shoot and root: Zinc content in shoot and root varied significantly with the inoculation of AM. The Zn content (52.45 µg g^{-1}) was higher when inoculated with AM and lower (49.10 µg g^{-1}) when without inoculation of AM (Table 4). It was also noted that Zn content 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 maize plant shoots and roots was significantly higher than without AMF. Significant variation was observed in Zn content in shoot and root due to the effect of different doses of P (Table 5). The highest Zn content (61.88 µg g^{-1}) was recorded due to the application of P @ 40 kg ha^{-1} which was superior to all. The lowest Zn content (40.88 µg g^{-1}) was recorded in P_{80} level. From the above results it was clear that the interaction between P and Zn in chilli plant was antagonistic. Rashid *et al.* (2008) noted that the highest Zn content (100.87 µg g^{-1}) in brinjal seedlings was found in 15 kg P ha^{-1}. The variation in Zn content due to interaction of arbuscular mycorrhiza and different levels of P was statistically significant (Table 6). The treatment P_{20} × I contained maximum Zn content (63.50 µg g^{-1}) which is better than to all other treatments. The treatment P_0 × U contain minimum Zn content (36.00 µg g^{-1}).

Zinc content in fruit: Application of AM significantly affected the Zn content in chilli fruit (Table 4). The Zn content (36.79µg g^{-1}) was higher in AM inoculated plant and lower (33.68 µg g^{-1}) in non inoculated plant. Zinc content differed significantly due to different levels of P application (Table 5). The highest Zn content (50.63 µg g^{-1}) was recorded due to the application of P @ 40 kg ha^{-1} which was superior to all. The lowest Zn content (28.50 µg g^{-1}) was recorded in P_0 level. The treatment combination of AM inoculation and levels of P varied significantly in Zn content (Table 6). The treatment P_{40} × I contain maximum Zn content (57.50 µg g^{-1}) which was the best than all other treatments. The treatment P_{80} × U contain minimum Zn content (26.50 µg g^{-1}).

Copper content in shoot and root: Application of AM significantly affect the Cu content in shoot and root of chilli plant (Table 4). Inoculation of AM produced higher Cu content (7.21 µg g^{-1}); whereas uninoculated treatment produced lower content (6.63 µg g^{-1}). Copper content in shoot and root of chilli differed significantly due to different levels of P application (Table 5). The highest Cu content (7.43 µg g^{-1}) was observed when the crop was fertilized with 40 kg P ha^{-1} that was superior to all P levels. On the other hand, the lowest content (6.36 µg g^{-1}) was recorded from P_{80} level. It was also mentioned that control treatment was better than higher level of P application for Cu content, which interacted antagonistically. Rashid *et al.* (2008) reported that the highest Cu content (34.16 µg g^{-1}) in brinjal seedlings was found in 15 kg P ha^{-1}. The treatment combination of AM inoculation and levels of P significantly varied Cu content in shoot and root of chilli plant (Table 6). The Cu content was the highest (7.91 µg g^{-1}) in P_{40} × I treatment which was significantly higher over all other treatment combinations. The lowest Cu content (6.33 µg g^{-1}) was found from P_{80} × U treatment combination. From these result, it was evident that Cu content in chilli plant decreased with increasing level of P.

Copper content in fruit: Copper content showed significant effect due to inoculation of AM in chilli fruit (Table 4). Higher Cu content (6.12%) was noted when the crop was inoculated with mycorrhiza. Lower Cu content (6.06%) was obtained from uninoculated treatment. Copper content in chilli fruit differed significantly due to P application (Table 5). The highest Cu content (6.89%) was observed when the crop was fertilized with 40 kg P ha^{-1} which was superior to all P levels. The lowest Cu content (5.20%) was obtained from P_{80} level. Interaction effect of inoculation of arbuscular mycorrhiza and different levels of P showed significant effect in Cu content (Table 6). The highest Cu content (7.04%) was produced by 40 kg P ha^{-1} × AM inoculant which was best of all combinations. P_{80} × U treatment combination produced the lowest Cu content (5.25%).

Boron content in shoot and root: There was a significant response of mycorrhizal inoculant on B content in shoot and root of chilli plant (Table 4). Inoculated plants gave significantly higher B content (17.22 µg g^{-1}) over uninoculated plant (15.14 µg g^{-1}).

Phosphorus application showed insignificant effect on the B content in chilli shoot and root. It was recorded that the B content (19.51 µg g^{-1}) was the highest at P_{60} level. The lowest B content (8.98 µg g^{-1}) was found from P_0 level (Table 5). Rashid *et al.* (2008) opined that P fertilization increased B content in brinjal seedlings positively up to a certain level and the highest B content (39.81 µg g^{-1}) was found in 30 kg P ha^{-1} and the lowest (25.44 µg g^{-1}) was found in 0 kg P ha^{-1}. There was insignificant effect on B content in the interaction effect of phosphorus × AM inoculant (Table 6). The maximum B content (21.60 µg g^{-1}) was recorded in P_{40} × I treatment combination. The minimum B content (7.15 µg g^{-1}) was observed in P_0 × U treatment combination.

Boron content in fruit: Inoculation of AM showed significant effect on B content of fruit (Table 4). Higher B content (14.47%) was produced when the crop was inoculated with mycorrhiza while lower B content (12.64%) was obtained from uninoculated treatment. Boron content differed significantly due to P application (Table 5). The highest B content (19.43%) was observed when the crop was fertilized with 40 kg P ha^{-1} that was superior to all other P levels. The lowest B content (8.84%) was obtained from P_0 treatment. Interaction of arbuscular mycorrhiza inoculation and different levels of P showed significant variation in B content of chilli fruit (Table 6). The highest B content (21.48%) was obtained from 40 kg P ha^{-1} × AM inoculant. Control treatment combination (P_0 × U) produced the lowest B content (8.38%).

References

BARC, 2005. Fertilizer Recommendation Guide. Published by BARC, Dhaka, Bangladesh.

BBS (Bangladesh Bureau of Statistics). 2004. Statistical Yearbook of Bangladesh. 24th edn. Dhaka. p-13.

Douds, D.D. and Millner, D. 1999. Biodiversity of arbuscular mycorrhizal fungi in agrocosystem. Agric. Ecosyst. Environ. 74: 77-93.

Ghosh, A.B., Bajoy, J.C., Hasan, R. and Singh, D. 1983. Soil and Water Testing Method. A Laboratory Manual, Division of Soil Science and Agricultural Chemistry. IARI, New Delhi. India.

Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi. pp. 151-154.

Masud, M.M., Mollik, S.A. and Noor, S. 2008. Effect of poultry manure in combination with chemical fertilizers on the yield and nutrient uptake by chilli in the hilly region. Annual Research Report, 2007-2008, Division of Soil Sci., Bangladesh Agril. Res. Inst., Joydebpur, Gazipur. pp. 224-226.

Page, A.L., Miller, R.H. and Keeney, D.R. 1982. Methods of Soil Analysis, Part-2. 2nd Edn. Amer. Soc. Agron. Inc. Medison, Washington, USA. pp. 98-765.

Rashid, M.A.M., Chowdhury, M.A.H. and Bhuiyan, M.A.H. 2008. Yield and nutritional changes in brinjal seedlings by arbuscular mycorrhizal inoculation under different P levels. J. Agrofor. Environ. 2(2): 15-21.

Richardson, A.E. 1994. Soil microorganisms and phosphorus availability. *In:* Soil Biota, Management in Sustainable Farming Systems, Pankhurst C.E., Doube B.M., Grupta V.V.S.R. and Grace P.R. Eds. Melbourne, Australia: CSIRO. pp. 50–62.

Russel, D.F. 1986. M-STAT Director. Crop and Soil Science Department. Michigan State University, USA.

Seres, A., Bakonyi, G. and Posta, K. 2006. Zn uptake by maize under the influence of AM-fungi and Collembola Folsomia. Ecol. Res. 21(5): 692-697.

Shil, N.C., Naser, H.M., Yusuf, M.N., Brahma, S. and Hossain, K. M. 2008. Response of chilli to zinc and boron fertilization. Annual Research Report, 2007-2008, Division of Soil Sci., Bangladesh Agril. Res. Inst., Joydebpur, Gazipur. pp. 261-267.

Smith, S.A. and D.J. Read. 1997. Mycorrhizal symbiosis. Academic Press, Cambridge.

Wolf, B. 1982. A comprehensive system of leaf analysis and its use for diagnostic crop nutrient status commun. Soil Sci. Plant Anal. 13(12): 1044-1045.