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Short Communication

Effect of Arbuscular Mycorrhizal Inoculum Rate on Tomato (*Lycopersicum esculenta* L.) Seedlings

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An experiment on the effect of rate of arbuscular mycorrhiza inoculum in producing tomato seedlings (var. Ratan) were conducted in the seedbed of Soil Science Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh during rabi season of 2007-08 and 2008-09. Seven rates of AM inoculum viz. 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 kg m^{-2} were studied on tomato seedlings. Cowdung was used at the rate of 5 kg m^{-2} as basal. Seeds were sown in 10 cm apart solid lines on 13 November 2007 and 11 November 2008, and the seedlings were thinned down to about 3 cm from seedling to seedling within a week of germination. Ratan was used as the variety of tomato. Biomass yield, seedling height and nutrient uptake by tomato seedlings increased greatly with the use of AM inoculum. Biomass yield of tomato seedlings followed quadratic trend with the increase of AM inoculum rate from 0 to 1.0 kg m^{-2} in 2007-08 and 0 to 2.0 kg m^{-2} in 2008-09.

Key words: ***Tomato, Arbuscular mycorrhiza, rate seedling***

Arbuscular mycorrhiza is the most common type, occurring in about 80% of the plant species. They are the most suitable type for development programs based on low-input agriculture[1]. Arbuscular mycorrhiza form symbiotic association with most of the terrestrial plants species[2-4]. About 90% of all plant species including most agricultural, horticultural, and tree crops form mycorrhizae[5]. More than 6,000 fungal species are capable of establishing mycorrhizas with about 240,000 plant species[6]. Arbuscular mycorrhiza occurs in about 83% of dicotyledonous and 79% of monocotyledonous plants[7]. All gymnosperms are reported to be mycorrhizal[8]. Arbuscular mycorrhiza fungal associations have been observed in 1000 genera of plants representing 200 families. Arbuscular mycorrhizal fungi benefit plant in a number of ways to increase plant productivity and to conserve soil to sustain future production. The major benefits of AM association are: (i) an increase in uptake of immobile nutrients particularly phosphorus and micronutrients[9-10]; (ii) higher production of growth regulating substances[11]; (iii) increase in rate of photosynthesis[12-13]; (iv) increase in uptake of water and osmotic adjustment under drought stress[12, 14]; (v) enhancement of symbiotic N_2-fixation through increased P supply[15]; (vi) resistance to pests and diseases[1, 16]; (vii) helps in the formation of soil aggregation and aggregate stability[17]; (viii) improves soil-plant-water relation[12, 18-19], and (ix) confers protection against toxic-metals[20-21]. Mycorrhizal association also helps in uptake of other macro-and micronutrients. A conservative estimate suggests that the external hyphae of AM can deliver up to 25% of N, 80% of P, 10% of K, 25% Zn and 60% of plant Cu[22]. The benefits from a mycorrhizal association depend largely on establishment of an effective association between the plant roots and AM fungus. Establishment of AM association depends on density and number of AM propagules (spore, mycelium, infected root pieces etc.) in the growing media. The present investigation was, therefore, undertaken to observe the effect of different rates of AM inoculum on the performance of tomato seedlings (var. Ratan).

An experiment on tomato seedlings was conducted in the seedbeds (3 m × 1 m) of Soil Science Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh during rabi season 2007-08 and 2008-09. Silted soil from the bank of Turag river at Kodda, Gazipur was used in the seedbed. The soil was slightly alkaline in reaction. Organic matter, major nutrients, and zinc and copper contents of the soil were low, while iron and manganese levels were quite high. The soil contained 10 AM spores of indigenous mixed AM fungal species and the experiment was conducted under non-sterilized soil condition.

The experiment was laid out in randomized complete block (RCB) design with four replications. Seven rates of AM inoculum viz. 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 kg m^{-2} were studied on tomato seedlings. The seed bed was divided into 7 separate unit plot by inserting thick polyethylene sheet up to 25 cm depth of soil to check the contamination of AM among the plots. Cowdung was used at the rate of 5 kg m^{-2} as basal. No other

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fertilizers were used. Seeds were sown in 10 cm apart solid lines on 13 November 2007 and 11 November 2008. Soil based AM inoculum was used in the seed furrows of about 3 cm depth. A soil layer of about 1 cm thickness was spread on the inoculum layer on which the seeds were sown. Ratan was used as the variety of tomato. The seedlings were thinned down to about 3 cm from seedling to seedling within a week of germination. Watering, weeding and other intercultural operation were done as and when necessary. The seedlings were harvested on 11 December 2007 and 17 December 2008. Data on biomass yield and yield components were recorded. The seedlings were harvested carefully by uprooting. Roots of the seedlings were washed to remove the adhered soils. Root samples were then excised for AM colonization studies. Plant samples were oven dried at 70°C until constant weight. Chemical analyses of the samples were done and nutrient uptake by the seedlings was calculated. Soil samples from the plot were collected during harvesting the seedlings for counting AM spore population. Hundred grams soil sample plot^{-1} was used to count the spore numbers. The spore numbers were determined by wet sieving and decanting method[23]. To assess AM root colonization, the roots were processed after Koske and Gemma[24] and observed under a compound microscope. Presence of fungal bodies (mycelium, spores, arbuscules and vesicles) in the root tissues were considered as positive for infection. Data were analyzed using the statistical package IRRISTAT and MSTAT-C.

Biomass yield of tomato seedlings (var. Ratan) has been presented in the Figs. 1 and 2. The biomass yield of the seedlings followed quadratic trend with the increase of AM inoculum rate. The response curve shows that the highest biomass (325 mg seedling^{-1} in 2007-08 and 430 mg seedling^{-1} in 2008-09) of tomato seedlings was produced with the AM inoculum rate of about 1.0 kg m^{-2} in 2007-08 and 2.0 kg m^{-2} in 2008-09. Similar trend in the yield components like seedling height, root length, number of leaves seedling^{-1}, collar diameter, shoot and root weight of the seedlings was also observed with the increase of AM inoculum rate (Table 1). Root colonization and spore population in tomato seedlings was found to increase with the increase of inoculum rate up to 2.0 kg m^{-2} and 2.5 kg m^{-2}, respectively in 2007-08, and 2.0 kg m^{-2} and 2.0 kg m^{-2}, respectively in 2008-09.

Uptake of all the major and minor nutrients increased greatly with AM inoculation, which might have enhanced the inoculated seedlings to produce more biomass and better growth compared to the non-inoculated seedlings (Tables 2 and 3.). Uptake of nutrients by non-inoculated seedlings was 6.36 mg N, 1.59 mg P, 6.91 mg K, 4.86 mg Ca, 1.18 mg Mg, 1.18 mg S, 63 µg B, 44.2 µg Cu, 789 µg Fe, 166 µg Mn and 77.0 µg Zn seedling^{-1} in 2007-08 and 7.87 mg N, 1.05 mg P, 10.3 mg K, 3.58 mg Ca, 1.92 mg Mg, 0.55 mg S, 122 µg B, 48.3 µg Cu, 1589 µg Fe, 216 µg Mn and 172 µg Zn seedling^{-1} in 2008-09. While uptake of nutrients by inoculated seedlings ranged from 7.48 to 11.34 mg N, 2.08 to 2.64 mg P, 9.15 to 12.00 mg K, 6.36 to 8.81 mg Ca, 1.56 to 1.90 mg Mg and 1.68 to 2.76 mg S, 82 to 165 µg B, 49.7 to 77.0 µg Cu, 773 to 1229 µg Fe, 189 to 255 µg Mn and 74.9 to 132.6 µg Zn seedling^{-1} in 2007-08 and 9.71 to 14.15 mg N, 1.52 to 2.19 mg P, 13.9 to 19.1 mg K, 5.11 to 7.08 mg Ca, 2.75 to 3.52 mg Mg, 0.75 to 1.19 mg S, 156 to 247 µg B, 61.3 to 89.9 µg Cu, 2073 to 3192 µg Fe, 305 to 404 µg Mn and 215 to 319 µg Zn seedling^{-1} in 2008-09. Trend in uptake of nutrients with increasing the rate was also observed.

From the results it is evident that the biomass yield, seedling height and nutrient uptake by tomato seedlings increased greatly with the use of AM inoculum. Biomass yield of tomato seedlings followed quadratic trend with the increase of AM inoculum rate.

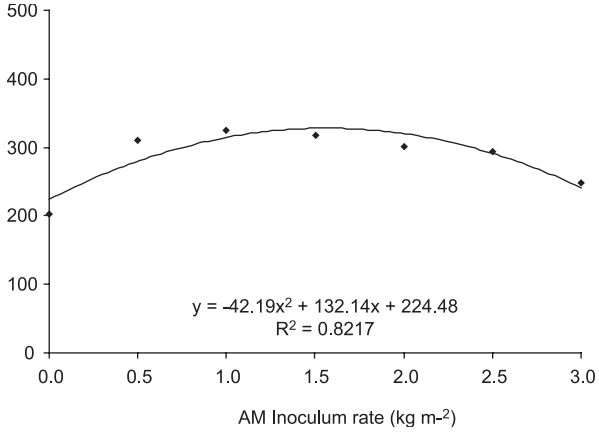

Figure 1. *Effect of AM inoculum rate on dry weight of tomato seedlings (var. Ratan) during 2007-08.*

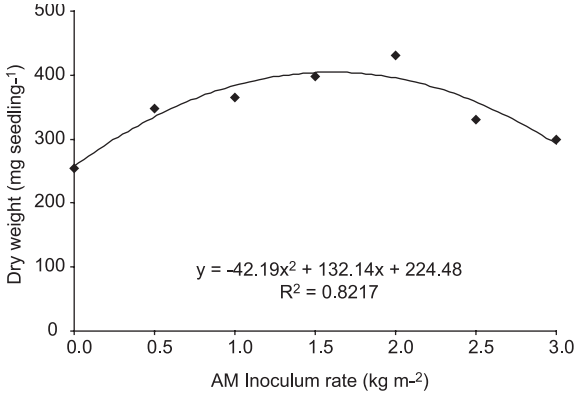

Figure 1. *Effect of AM inoculum rate on dry weight of tomato seedlings (var. Ratan) during 2008-09.*

Table 1. *Effect of rate of AM inoculum on the yield and yield components of tomato seedlings (var. Ratan) during rabi season of 2007-08 and 2008-09*

AM Inoculum rate (kg m^{-2})	Seedling height (cm)	Root length (cm)	Collar diameter (mm)	No. of leaves $seedling^{-1}$	Shoot weight (mg $seedling^{-1}$)	Root weight (mg $seedling^{-1}$)	Root colonization (%)	Spore no. (100^{-1} g soil)
2007-08								
0	14.7	5.1	2.15	4.30	181	22c	10.0d	10.0d
0.5	17.7	7.4	3.11	5.40	266	45ab	30.0c	15.0cd
1.0	18.9	7.4	3.10	5.40	277	48ab	40.0bc	20.0cd
1.5	22.9	5.9	3.31	5.50	265	52a	60.0a	25.0bc
2.0	20.0	5.9	2.72	5.20	247	54a	45.0b	35.0b
2.5	17.4	5.7	2.72	5.10	260	33bc	40.0bc	55.0a
3.0	17.4	5.7	2.65	5.30	223	26c	40.0bc	50.0a
F Test	NS	NS	NS	NS	NS	**	**	**
CV (%)	12.2	10.3	12.7	8.6	12.8	15.4	14.7	16.3
2008-09								
0	20.6c	5.7	2.56	5.20	223d	32	25.0d	20.0d
0.5	27.4ab	6.4	2.70	5.40	307abc	41	30.0d	25.0d
1.0	28.6ab	7.1	2.78	5.85	323abc	42	40.0c	40.0c
1.5	28.8ab	7.4	2.99	6.05	355ab	43	50.0b	50.0b
2.0	30.7a	7.3	3.15	5.90	380a	50	60.0a	60.0a
2.5	24.3bc	7.3	2.97	5.15	283bcd	48	60.0a	50.0b
3.0	24.1bc	7.1	2.86	5.35	259cd	40	55.0ab	50.0b
F Test	**	NS	NS	NS	**	NS	**	**
CV (%)	12.3	15.3	14.8	10.0	15.8	19.4	12.9	15.4

Means followed by common letter are not significantly different at 5% level by DMRT

Table 2. *Effects of rate of AM inoculum on uptake of major nutrients by tomato (var. Ratan) seedlings during rabi seasons of 2007-08 and 2008-09*

AM Inoculum rate (kg m^{-2})	Uptake of major nutrients (mg $seedling^{-1}$)					
	N	P	K	Ca	Mg	S
2007-08						
0	6.36d	1.59c	6.91c	4.86c	1.18	1.18d
0.5	9.60abc	2.67a	10.66ab	7.43ab	1.73	2.76a
1.0	11.34a	2.64ab	12.00a	8.81a	1.90	2.54ab
1.5	11.07ab	2.58ab	11.52ab	7.58ab	1.58	2.10bc
2.0	9.01bc	2.14ab	11.60ab	7.35ab	1.71	2.02bc
2.5	8.51cd	2.08bc	9.25bc	6.48bc	1.56	2.03bc
3.0	7.48cd	2.38ab	9.15bc	6.36bc	1.63	1.68c
F test	*	*	*	*	NS	**
CV(%)	10.0	9.4	9.9	10.0	9.7	10.1
2008-09						
0	7.87c	1.05c	10.3d	3.58c	1.92c	0.55d
0.5	11.66ab	1.59b	13.9c	5.11b	2.76b	0.75c
1.0	11.58ab	1.55b	15.6bc	5.63b	2.97ab	0.78c
1.5	14.00a	1.77b	19.1a	5.81b	3.24ab	1.03ab
2.0	14.15a	2.19a	18.5ab	7.08a	3.52a	1.19a
2.5	11.15b	1.67b	15.3bc	5.26b	2.96ab	0.91bc
3.0	9.71bc	1.52b	14.3c	5.11b	2.75b	0.87bc
F test	**	**	**	**	**	**
CV(%)	14.6	15.2	14.1	15.5	13.6	14.8

Means followed by common letter are not significantly different at 5% level by DMRT

Table 3: *Effects of rate of AM inoculum on uptake of minor nutrients by tomato (var. Ratan) seedlings during rabi seasons of 2007-08 and 2008-09*

AM Inoculum rate (kg m^{-2})	Uptake of minor nutrients (µg $seedling^{-1}$)				
	B	Cu	Fe	Mn	Zn
2007-08					
0	63c	44.2c	789c	166c	77.0d
0.5	158a	77.0a	1229a	255a	114.3ab
1.0	165a	74.1a	1141ab	224ab	132.6a
1.5	110b	71.1a	1115ab	244ab	97.8bcd
2.0	96b	63.6ab	1151ab	238ab	110.8abc
2.5	82bc	49.7bc	963bc	189bc	89.2cd
3.0	104b	50.4bc	773c	207abc	74.9d
F test	**	**	*	*	**
CV(%)	10.8	9.8	9.5	10.0	9.7
2008-09					
0	122d	48.3d	1589c	216c	172d
0.5	215ab	71.1bc	2202b	333ab	252bc
1.0	233a	74.7bc	2742a	370ab	250bc
1.5	262a	83.4ab	2748a	370ab	299ab
2.0	247a	89.9a	3192a	404a	319a
2.5	181bc	64.3c	2073bc	310b	224cd
3.0	156cd	61.3cd	2086bc	305b	215cd
F test	**	**	**	**	**
CV(%)	14.9	13.8	14.6	14.8	14.2

Means followed by common letter are not significantly different at 5% level by DMRT

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