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EFFECT OF RATE OF ARBUSCULAR MYCORRHIZA INOCULUM ON TOMATO *(Solanum lycopersicum)* SEEDLINGS

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Abstract

An experiment on the effect of rate of Arbuscular mycorrhiza (AM) inoculum on tomato seedlings was conducted at Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh for two consecutive years. Seven rates of AM inoculum viz., 0, 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 kg/m^2 were tested. Cowdung was used at a rate of 5 kg/m^2. Seeds were sown in 10 cm apart lines on 13 November 2007 and 11 November 2008, and the seedlings were thinned out to about 3 cm from seedling to seedling within a week of germination. Roma VF was used as a variety of tomato. Biomass yield, root colonization, spore number, and nutrient uptake by tomato seedlings increased remarkably with the rates of AM inoculum. The biomass yield followed a quadratic trend with the increase of AM inoculum rate from 0 to 2.0 kg/m^2 in 2007-08 and 0 to 1.5 kg/m^2 in 2008-09.

Keywords: Tomato seedlings, Arbuscular mycorrhiza, nutrient uptake.

Introduction

Arbuscular mycorrhiza form symbiotic association with most of the terrestrial plants species (Azizah, 1999; Richardson *et al*., 2000; Sramek *et al*., 2000). About 90% of all plant species including most agricultural, horticultural, and tree crops form mycorrhizae (Read *et al*., 1992). More than 6,000 fungal species are capable of establishing mycorrhizas with about 240,000 plant species (Bonfante and Perotto, 1995). Arbuscular mycorrhiza is the most common type occurring in about 80% of the plant species. They are the most suitable type for development programmes based on low-input agriculture (Bethelenfalvay and Linderman, 1992). Arbuscular mycorrhiza occurs in about 83% of dicotyledonous and 79% of monocotyledonous plants (Trappe, 1987). All gymnosperms are reported to be mycorrhizal (Newman and Reddell, 1987). 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) increase uptake of immobile nutrients particularly phosphorus and micronutrients (Azizah and Martin, 1992; Douds and Millner, 1999); (ii) higher production of growth regulating substances

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(Danneberg *et al*., 1992); (iii) increase rate of photosynthesis (Masri, 1997; Syvertsen and Graham, 1999); (iv) increase uptake of water and osmotic adjustment under drought stress (Auge *et al*., 1986; Masri, 1997); (v) enhancement of symbiotic N_2-fixation through increase P supply (Kucey and Paul, 1982); (vi) resistance to pests and diseases (Bethlenfalvay and Linderman, 1992; Ho, 1998); (vii) helps in the formation of soil aggregation and aggregate stability (Azizah and Idris, 1996); (viii) improves soil-plant-water relation (Kothari *et al*., 1990; Masri, 1997; Jastrow *et al*., 1998), and (ix) confers protection against toxic-metals (Azizah *et al*., 1989; Bonifacio *et al*., 1999). 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 (Marschner and Dell, 1994).

However, 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.

Materials and Method

An experiment on tomato seedlings was conducted in the seedbeds (3 m × 1 m) of Soil Science Division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh during the rabi season of 2007-08 and 2008-09. Silted soil from the bank of Turag river at Kodda, Gazipur was used in the seedbed. The soil of the seedbed was sandy clay loam in texture having pH 7.4, organic matter 0.53%, total N 0.03%, available P 11.0 μg/g, available S 10.0 μg/g, exchangeable K 0.15 meq/100g, exchangeable Ca 3.80 meq/100g, exchangeable Mg 1.10 meq/100g, available Zn 2.50 μg/g, available B 0.14 μg/g, available Cu 2.10 μg/g, available Fe 35 μg/g, and available Mn 11 μg/g. 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 mixed AM inoculum viz., 0, 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 kg/m^2 were studied on tomato seedlings. The seed bed was divided into seven separate unit plot by inserting thick polyethylene sheet upto 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. No other fertilizers were used. Seeds were sown in 10 cm apart 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. Roma VF 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. Plant samples were oven dried at 70^{o}C until constant weight. Chemical analyses of the samples were done and nutrient uptake by the seedlings was calculated. Data were analyzed using the statistical package IRRISTAT.

Results and Discussion

Performance of tomato seedlings

Biomass yield of tomato seedlings has been presented in Fig. 1. The biomass yield of the seedlings followed quadratic trend with the increase of AM inoculum rate. The response curve shows that the highest biomass (435 mg per seedling in 2007-08 and 399 mg per seedling in 2008-09) of tomato seedlings was produced with the AM inoculum rate of about 2.0 kg per m^2 in 2007-08 and 1.5 kg per m^2 in 2008-09. Similar trend in shoot and root weight of the seedlings was also observed with the increase of AM inoculum rate (Table 1). Better performance of inoculated seedlings might be due to beneficial effects of AM fungi. There are many evidence of better performance of AM inoculated seedlings compared to those without inoculation (Masri, 1997; Satter, 2000 and Satter and Khanam, 2002). Root colonization and spore number in tomato seedlings was found to increase with the increase of inoculum rate up to 2.0 to 2.5 kg per m^2. There was also some root colonization in the control seedlings with native AM fungi. This might be due to survival of some native AM fungi in soil.

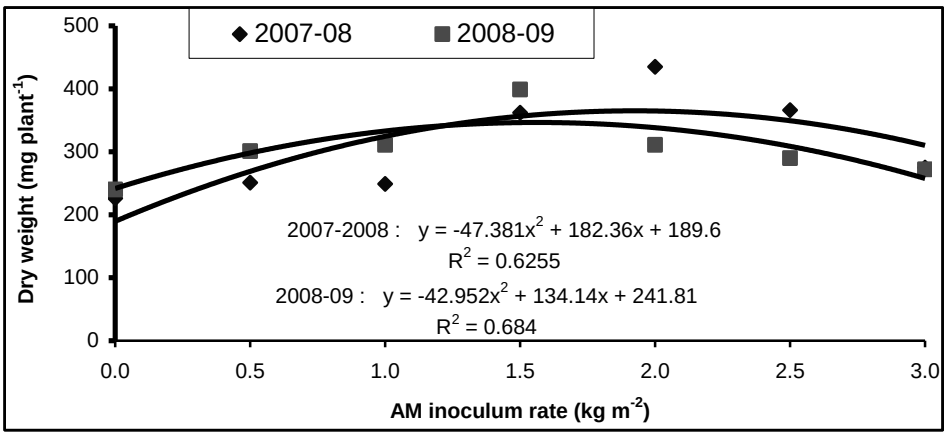

Fig. 1. Effect of AM inoculum rate on dry weight of tomato seedlings.

Table 1. Effect of rate of AM inoculum on root weight, shoot weight, root colonization and spore numbers of tomato seedlings in seedbed in 2007-08 and 2008-09.

Inoculum rate (kg/m^2)	2007-08				2008-09			
	Shoot wt (mg/ seedling)	Root wet (mg/ seedling)	Root coloniza-tion (%)	Spore no. (100/ g soil)	Shoot wt (mg/ seedling)	Root wt (mg/ seedling)	Root coloniza-tion (%)	Spore no. (100/ g soil)
0	204b	22c	20.0c	10.0d	216b	24c	25.0d	20.0d
0.5	225b	26c	25.0c	15.0cd	268b	33bc	30.0cd	25.0d
1.0	214b	35c	30.0c	20.0cd	272b	39ab	35.0c	40.0c
1.5	304a	58b	40.0b	25.0bc	355a	44a	50.0b	50.0b
2.0	357a	78a	60.0a	35.0b	270b	41ab	55.0ab	60.0a
2.5	329a	37c	50.0ab	55.0a	249b	41ab	60.0a	50.0b
3.0	236b	39c	40.0b	50.0a	235b	37ab	55.0ab	50.0b
F Test	**	**	**	**	*	*	**	**
CV (%)	10.4	18.3	14.7	16.3	20.3	18.7	14.2	15.4

Means followed by common letter(s) are not significantly different at 5% level by DMRT.

Nutrient uptake by tomato seedlings

Nutrient uptake by tomato seedlings has been presented in Tables 2 and 3. Uptake of all the major and minor nutrients increased significantly with AM inoculation which might have enhanced the inoculated seedlings to produce more biomass and better growth compared to the non-inoculated seedlings. Uptake of nutrients by non-inoculated seedlings were 7.47 mg N, 1.89 mg P, 7.13 mg K, 5.48 mg Ca, 1.29 mg Mg, 0.99 mg S, 94 µg B, 47.7 µg Cu, 932 µg Fe, 161 µg Mn, and 84.6 µg Zn per seedling in 2007-08, and 7.67 mg N, 0.81 mg P, 3.44 mg K, 3.26 mg Ca, 1.67 mg Mg, 0.44 mg S, 101µg B, 41.8 µg Cu, 1450 µg Fe, 271µg Mn, and 166 µg Zn per seedling in 2008-09, respectively (Table 2 and 3). While uptake of nutrients by inoculated seedlings ranged from 7.69 to 12.99 mg N, 2.10 to 3.71 mg P, 8.55 to 14.96 mg K, 6.21 to 11.36 mg Ca, 1.27 to 2.48 mg Mg, and 1.78 to 3.06 mg S, 99 to 175 µg B, 53.7 to 89.3 µg Cu, 827 to 1734 µg Fe, 211 to 324 µg Mn and 90.8 to 156.9 µg Zn per seedling in 2007-08 and 8.69 to 13.29 mg N, 1.09 to 1.43 mg P, 4.64 to 6.09 mg K, 4.39 to 6.53 mg Ca, 2.34 to 3.23 mg Mg and 0.58 to 0.73 mg S, 133 to 214 µg B, 57.0 to 79.8 µg Cu, 1753 to 2747 µg Fe, 331 to 463 µg Mn, and 183 to 275 µg Zn per seedling in 2008-09. Trend in uptake of nutrients in most of the cases with increasing the rate of AM inoculum up to 2.0 kg per m^2 in 2007-08 and 1.5 kg per m^2 in 2008-09 was also

observed. The external hyphae can extend up to several centimeters beyond the mycorrhizal root surface and can increase root surface area and the absorption zone for exploration of greater soil volume for nutrient and moisture uptake (Johansen *et al*., 1993). Mycorrhizal fungal hyphae were found to intercept labeled P placed 27 cm apart from a mycorrhizal root, whereas it remained unavailable to non-mycorrhizal roots (Hattingh *et al*., 1973). The radius of the depletion zone for P around mycorrhizal onion roots was found twice that for non-mycorrhizal roots (Owusu-Bennoah and Wild, 1980). The rate of nutrient uptake by mycorrhizal roots is also faster than that by non-mycorrhizal roots (Son and Smith, 1988).

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

AM Inoculum rate (kg/m^2)	Uptake of macronutrients (mg/seedling)					
	N	P	K	Ca	Mg	S
2007-08						
0	7.47b	1.89d	7.13d	5.48c	1.29b	0.99e
0.5	7.93b	2.10c	8.55cd	6.42c	1.43b	1.78d
1.0	8.35b	2.21c	9.57cd	6.21c	1.27b	2.11cd
1.5	12.99a	3.55a	12.34b	9.45b	2.48a	2.77ab
2.0	12.80a	3.71a	14.80a	11.36a	2.27a	3.06a
2.5	12.26a	3.35ab	14.96a	9.12b	2.15a	2.52bc
3.0	7.69b	2.31c	10.54bc	6.59c	1.60b	1.90d
F test	**	**	**	**	**	**
CV(%)	9.7	9.5	8.7	9.2	9.7	8.9
2008-09						
0	7.67b	0.81b	3.44b	3.26c	1.67c	0.44b
0.5	10.72ab	1.09ab	5.04a	5.03ab	2.42bc	0.62ab
1.0	10.00b	1.43a	4.66ab	5.35ab	2.70ab	0.58ab
1.5	13.29a	1.40a	6.09a	6.53a	3.23a	0.72a
2.0	10.62ab	1.15ab	5.29a	4.69bc	2.34bc	0.73a
2.5	9.50b	1.17ab	4.64ab	4.39bc	2.47abc	0.71a
3.0	8.79b	1.10ab	4.79ab	4.52bc	2.41bc	0.68a
F test	*	*	*	**	*	*
CV(%)	19.1	19.7	18.8	20.5	20.0	19.3

Means followed by common letter(s) are not significantly different at 5% level by DMRT.

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

AM Inoculum rate (kg/m^2)	Uptake of micronutrients (µg/seedling)				
	B	Cu	Fe	Mn	Zn
2007-08					
0	94b	47.7b	932d	161c	84.6c
0.5	105b	53.7b	1023cd	211bc	95.3c
1.0	102b	53.2b	827d	231b	89.4c
1.5	150a	79.3a	1209c	324a	122.3b
2.0	175a	89.3a	1734a	314a	156.9a
2.5	157a	75.9a	1470b	314a	138.6ab
3.0	99b	60.5b	965cd	234b	90.8c
F test	**	**	**	**	**
CV(%)	9.2	9.2	8.7	9.1	8.8
2008-09					
0	101c	41.8c	1450c	271c	166b
0.5	133bc	57.0bc	1814bc	378abc	213ab
1.0	140bc	63.7ab	2154ab	367abc	224ab
1.5	214a	79.8a	2747a	463a	275a
2.0	164ab	66.5ab	1856bc	397ab	221ab
2.5	167ab	62.2ab	1921bc	352abc	209b
3.0	143bc	63.7ab	1753bc	331bc	183b
F test	**	*	**	*	*
CV(%)	21.2	19.2	20.7	19.2	18.8

Means followed by common letter(s) are not significantly different at 5% level by DMRT.

From the results, it is evident that the biomass yield, root colonization, spore number in rhizosphere soil and nutrient uptake by tomato seedlings increased significantly with the use of AM inoculum. Biomass yield of tomato seedlings followed quadratic trend with the increase of AM inoculum rate.

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