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EFFECT OF MYCORRHIZATION ON GROWTH, YIELD AND QUALITY OF GREENHOUSE GROWN TOMATOES

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ABSTRACT

Tomato is a known commercial and nutritious vegetable belonging to Solanaceous family with high lycopene content, ascorbic acid, dietry fibres, beta-carotene etc. and therefore also known as Poor man's apple. Greenhouse cultivation of tomato is preferable sustainable strategy for higher yields, year-round production, and protection against various biotic and abiotic stresses due to controlled environmental conditions. But soil borne diseases offer major challenge for any polyhouse grower and need some alternative like mycorrhiza major yield losses with the use of much chemicals under protected cultivation. Mycorrhizal association also known as symbiotic relationship between plant roots and fungi, are crucial for plant health as they help the host plants to thrive in adverse soil conditions and combat the issue of soil borne pathogens in a sustainable manner by increasing the root surface area along with increased mineral uptake efficiency. By keeping all the things in mind an investigation on "Effect of mycorrhization on growth, yield and quality attributes of greenhouse tomato" was conducted at CCS HAU, Hisar to find out the method of mycorrhiza inoculation (*Glomus mosseae*) on growth, yield and quality characters of greenhouse tomatoes var. Pusa Ruby. Doses of mycorrhizal sporocarps and methods of inoculation had differential effect on growth, yield and quality parameters. During the study, 500 sporocarps per kg of soil (D_1) when applied through soil mix method (M1) gave maximum growth, marketable yield (283.50 q/ha) and TSS (5.57 ºB), mycorrhiza colonization (45.46%) and mycorrhiza inoculation effect (12.50%) while minimum growth, marketable yield (237.41 q/ha) and TSS 4.9ºB.

***Keywords*:** Tomato, mycorrhiza, growth, quality, marketable yield, sporocarps and inoculation.

Introduction

Solanum lycopersicon, formerly known as genus lycopersicon, is a group of 13 closely related species that includes domesticated tomato and its wild relatives (Peralta *et al*., 2007). Tomato (*Solanum lycopersicum*) belongs to Solanaceae family and has high economic importance. It is a rich source of lycopene content (an antioxidant), ascorbic acid and beta-carotene which provide color and taste to it along with dietary fibres (Wilcox *et al*., 2003). It has antioxidant rich properties due to which it is very effective against cancer and heart diseases. It also helps in blood purification and act as an antiseptic for the intestine.

It is a short duration crop and has high production potential. It is also exported to other countries to earn foreign income. It is a warm season crop. It can be potentially grown in diverse climatic conditions round the year (Hazra and Som, 2015). It has more commercial significance for farmers due to its cultivation in both protected and open field environment. Its greater adaptability, higher economic returns and use of different varieties in fresh and processed food industries, make it globally relevant. For proper growth and development, tomato requires high temperature and humidity, as well as the application of various agronomic inputs like fertilizers, micronutrients.

Mycorrhiza is the most prevalent form of symbiosis relationship between plant roots and soil born fungi. Since most of the economically important plant form mycorrhiza, the subject is gaining importance in agriculture, horticulture and forestry research. Arbuscular Mycorrhiza (AM) is well known for their plant growth promoting efficiency and providing bio protection against soil borne pathogens (bacteria, fungal and parasitic nematode). The increased or more efficient use of mycorrhizal fungi may reduce the use of fertilizer (Erceg *et al*., 1990).

The arbuscular mycorrhizal fungi (AMF) found associated with the majority of land plants including those of the arid areas (Stutz *et al*., 2000), once it established than it increases mineral nutrition uptake, mainly phosphorus and enhance plant growth. VAM not only increase the uptake of phosphorous, but also helps in uptake of zinc, copper, sulphur, potassium and calcium (Cooper and Tinker, 1978). Additionally, it protects plants against environmental stress such as soil salinity (Giri *et al*., 2003), drought (Al-Karaki *et al*., 2004) and pathogens such as Fusarium wilt (Habte et al., 1999). Arbuscular mycorrhizal fungi (M^+) are widespread and commonly used plant symbiont and it stimulates plant uptake of nutrient such as Fe, Zn, Cu and P in deficient soil (Liu *et al*., 2000).

Mycorrhization has been shown to positively influence tomato growth by enhancing root architecture, increasing water and nutrient uptake efficiency, and stimulating plant metabolic activity. These effects collectively contribute to improved vegetative growth and reproductive development, ultimately leading to higher yields. In addition to quantitative benefits, AMF inoculation can also enhance qualitative attributes of tomato fruits, such as increasing concentrations of lycopene, vitamin C, soluble sugars, and antioxidants, which are important for both consumer health and market value. However, a little work has been done on arbuscular mycorrhiza in tomato, therefore it was planned to study the impact of arbuscular mycorrhiza on tomato growth, yield and quality.

Materials and Methods

The investigation on titled “Effect of mycorrhization on growth, yield and quality attributes of greenhouse tomato” was carried out in the polyhouse at Vegetable Grafting unit, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during the winter season of the year 2022-2023.The area was situated at 29º10'N latitude and 75 46'E longitude at an altitude of 215.2 meter above the sea level on south western border of the Rajasthan state and at a distance of about 175 km in west of the national capital city New Delhi. The experimental area belongs to the Agro-ecological zone–VI, which is known as “Trans-Gangetic plains region”. The soil texture of experimental site was sandy loam with pH 7.6, E.C. of 1.36 dS/m and organic carbon of 0.60 %. Available nitrogen, phosphorus and potassium contents were 122.7, 14.5 and 212 kg/ha respectively. The variety “Pusa Ruby” of tomato was grown with the recommended cultural practices. The crop was transplanted on 6th November 2022 with Completely randomized design (CRD) having three replications with seven treatments in each replication. All agronomic practices were followed timely for successful raising the crop. The treatment details are as below:

Factor A: Number of sporocarps per kg of soil/ Doses of mycorrhiza (D)

1. 500 sporocarps/kg of soil (D1)
2. 1000 sporocarps/kg of soil (D2)
3. 1500 sporocarps/kg of soil (D3)
4. No inoculation (D0)

Factor B: Method of inoculation (M)

1. Inoculum through infected soil or soil mix method (M1)
2. Seedling Dip: 30 min (M2)

In mycorrhizal inoculum through infected soil/ soil mix method mycorrhizal inoculum (promising mycorrhiza) containing about 500-1500 sporocarps will be prepared. According to treatment infected soil was mixed with upper 5 cm soil layer of greenhouse soil and In mycorrhizal inoculum through seedling dip (30 min) mycorrhizal inoculum (promising mycorrhiza) containing about 500-1500 sporocarps suspension was prepared and seedling were inoculated by dipping them in this suspension for 30 minutes inoculated seedlings were transplanted in soil under polyhouse.

Results and Discussion

In the present study, it was found that maximum plant height (77.48 cm) at 60 after transplanting was reported in treatment D1 i.e., 500 sporocarps per kg of soil while treatments D2 (75.00 cm) and D 3 (74.85 cm) varied non-significantly with each other, as mentioned in Table 1. The minimum plant height at 60 days after transplanting was recorded in Do (control) i.e. 68 cm. Similar pattern was observed in plant height at 90 days where all the mycorrhiza inoculated treatments were found significantly superior to control (Do). The increased growth with mycorrhization may be due to the increased nutrient uptake. AMF are known to increase the supply of unavailable and immobile nutrients by translocating them from the soil through their hyphae to the plants. Along with this, mycorrhiza also made available sufficient water quantity to the plant by absorbing it from the soil. This increased supply of nutrients such as phosphorus, copper, iron and zinc, mainly results in proper cell division and cell elongation, leading to increased plant height as compared to control. Greater plant height may also be due to a greater leaf area index than the normal control plant, where mycorrhizal application resulted in large amount of carbohydrate synthesis during the process of photosynthesis. These results are in conformity with the findings of Edathil *et al.* (1996); Mamatha *et al.* (2003); Alfonso and Galan (2006); Utkhede (2006); Chakraborty *et al.* (2008); Oseni *et al.* (2010); Hadad *et al.* (2012) and Bhuvaneshwari *et al.* (2014).

Response of mycorrhiza treatments on yield and yield related attributes are presented in Table 2. The maximum number of truss per plant and number of fruits per plant and marketable yield/plant was recorded in treatment D1 *i.e.*, 500 sporocarps per kg of soil while, treatment D2 *i.e.*, 1000 sporocarps per kg of soil and D3 *i.e.*, 1500 sporocarps per kg of soil varied non-significantly with the treatment D1 (as shown in table 2). The possible reason for the positive effect of mycorrhization on yield and yield contributing characters is the increased phosphorus content in plants. Phosphorus is an essential nutrient for plant growth and development. It is involved in cell division, energy storage, and many other processes. Mycorrhiza help plants to access phosphorus from the soil that would otherwise be unavailable. This increased phosphorus availability can lead to an increased yield and yield contributing characters of tomato plant. This finding is consistent with the work of Terry and Ruiz (2008) in their tomato; Malik and Kumar (2009); Al-Saidy and Muslih (2009); Perez *et al.* (2010); Sirichaiwetchakul *et al.* (2011); Nedorost and Pokluda (2012); Hadad *et al.* (2012) Nzanza *et al.* (2011); on tomato; Banu *et al.* (2013); Castillo *et al.* (2013) on Chilean pepper plants and Guruhurthy *et al.* (2014) on chilly. The studies reported that mycorrhiza treatment increased photosynthetic rate and stomatal conductance, which may have contributed to the increased yield of tomato plant. Chakraborty *et al.* (2008) also found that mycorrhiza treatment increased the total yield of tomato plant.

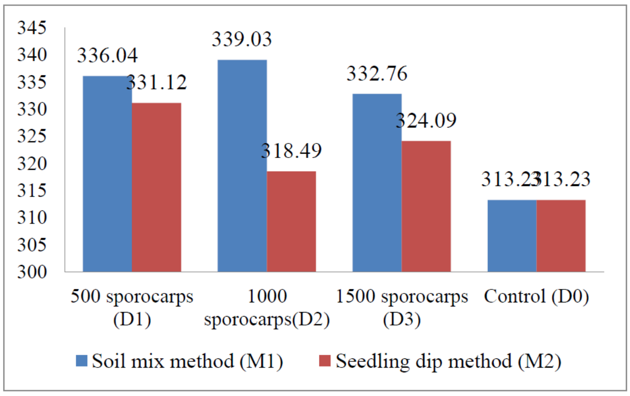

Fig. 1: Effect of different doses (D) of mycorrhiza and method of inoculation (M) on fruits yield per ha in greenhouse tomato

Table 1: Effect of different doses (D) of mycorrhiza and method of inoculation (M) on growth of greenhouse tomato.

Doses of mycorrhiza (D)	Plant height at 60 days			Plant height at 90 days		
	Soil mix method (M_1)	Seedling dip method (M_2)	Mean D	Soil mix method (M_1)	Seedling dip method (M_2)	Mean D
500 sporocarps (D_1)	77.73	**77.23**	**77.48**	138.30	140.97	**139.63**
1000 sporocarps (D_2)	74.00	**76.00**	**75.00**	136.00	141.00	**138.50**
1500 sporocarps (D_3)	76.00	**73.70**	**74.85**	134.70	139.37	**137.03**
Control (D_0)	68.00	68.00	68.00	134.00	134.00	134.00
Mean M (method)	**73.93**	**73.73**		**135.75**	**138.83**	
Mean P (Parameter)	73.83			137.29		
C.D. at 5%	**Factor D -2.64**	**Factor M-NS**	**D x M- NS**	**Factor D -2.66**	**Factor M-1.88**	**D x M- NS**

Table 2: Effect of different doses (D) of mycorrhiza and method of inoculation (M) on yield parameters of greenhouse tomato

Doses of mycorrhiza (D)	Number of truss per plant			Number of fruits per truss			Total marketable yield (q/ha)		Mean
	Soil mix method (M_1)	Seedling dip method (M_2)	Mean D	Soil mix method (M_1)	Seedling dip method (M_2)	Mean D	Soil mix method (M_1)	Seedling dip method (M_2)	
500 sporocarps (D_1)	**15.64**	**15.4**	**15.52**	**9.83**	8.47	**9.15**	283.50	278.16	**280.83**
1000 sporocarps (D_2)	**16.00**	14.03	**15.02**	9.03	9.20	**9.12**	273.32	274.55	**273.94**
1500 sporocarps (D_3)	**15.67**	14.30	**14.98**	8.60	9.47	**9.03**	270.23	267.85	269.04
Control (D_0)	14.33	14.33	14.33	8.20	8.20	8.20	237.41	237.41	237.41
Mean M (Method)	**15.41**	14.51		8.92	8.83		266.12	264.49	
Mean P	14.96			8.87			265.30		
C.D. at 5%	**Factor D -0.60; Factor M-0.43; DxM- 0.85**			**Factor D -0.55; Factor M-NS; DxM- 0.78**			**Factor D -7.73; Factor M- NS; DxM- NS**		

Effect of mycorrhization on Mycorrhizal parameters

The treatment comprising of different doses mycorrhiza (*Glomus mosseae*) and methods of inoculation significantly reduced the incidence of Fusarium wilt in tomato plants as shown in table 4. The maximum (6.66%) disease incidence was observed in the control (D0) with no inoculation of mycorrhiza. The minimum disease incidence was observed in the treatment D1 with 500 sporocarps per kg of soil (1.48%). These findings were consistent with the work of Srimeena and Kumari (2014) and Devi *et al.* (2022). Srimeena and Kumari (2014) found that mycorrhizal plants produce antimicrobial chemicals, which are important in reducing root fungal pathogen infection and consequently improving crop plant development and productivity. Devi *et al.* (2022) also found that endophytic AMF (*F. mosseae* and *G. fasciculatum*) are safe and effective biocontrol agent against the Fusarium wilt of tomato.

The application of different doses of mycorrhiza and method of inoculation had significant effect on mycorrhiza colonization (%). The maximum mycorrhiza colonization was observed in treatment D1 (45.46) i.e., 500 sporocarps per kg of soil while, treatment D2 i.e., 1000 sporocarps per kg of soil and D3 i.e., 1500 sporocarps per kg of soil varied non-significantly with the treatment D1. Chakraborty *et al.* (2008), Al-Saidy and Muslih (2009), Joshi *et al.* (2013) and Bakr *et al.* (2017) also found similar results related to mycorrhiza colonization in roots.

The effect of different doses and methods of inoculation of mycorrhiza (*Glomus mosseae*) increased the number of mycorrhiza spores/100gram of soil significantly. The maximum number of mycorrhiza spores/100gram of soil was analyzed in D1 i.e., 500 sporocarps per kg of soil (43.13) while, treatment D2 (40.83) i.e., 1000 sporocarps per kg of soil and D3 (40.08) *i.e.,* 1500 sporocarps per kg of soil varied non-significantly with treatment D1. The minimum number of mycorrhiza spores/100gram of soil was analyzed in control having no mycorrhiza (0.00). Among the method of application of mycorrhiza M1 *i.e.,* soil mix method (31.91) was significantly higher than M2 *i.e.,* seedling dip method (30.12) and the interaction between number of sporocarps and method of application of mycorrhiza had no significant effect on of mycorrhiza spores/100gram of soil. These results were in confirmation with the earlier work of Banu *et al.* (2013).

There was no significant effect of different doses of mycorrhiza (Glomus mosseae) and method of inoculation on mycorrhizal dependency (MD). However, different doses (D) of mycorrhiza had shown significant effect on mycorrhiza inoculation effect (MIE) i.e., maximum mycorrhiza inoculation effect was analyzed in 500 sporocarps per kg of soil (D1) while no mycorrhizal inoculation effect was observed in on control (0.00). These results were in confirmation with the earlier work of Utkhede (2006); Tahat *et al.* (2008); Ortas *et al.* (2013) and Bakr *et al.* (2017).

Table 3: Effect of different doses (D) of mycorrhiza and method of inoculation (M) on mycorrhizal parameters of greenhouse tomato.

Doses of mycorrhiza (D)	Disease incidence (%)			Mycorrhiza inoculation effect (MIE)		
	Soil mix method (M_1)	Seedling dip method (M_2)	Mean D	Soil mix method (M_1)	Seedling dip method (M_2)	Mean D
500 sporocarps (D_1)	0.74	2.22	1.48	12.8	12.2	12.5
1000 sporocarps (D_2)	2.22	1.48	1.85	11.27	12.57	11.92
1500 sporocarps (D_3)	2.22	2.22	2.22	10.23	11.33	10.78
Control (D_0)	6.66	6.66	**6.66**	0	0	0
Mean M (method)	2.96	3.15		11.43	12.03	
Mean P (Parameter)	3.05			11.73		
C.D. at 5%	Factor D -2.31; Factor M- NS; DxM- NS			Factor D –1.37; Factor M- NS; DxM- NS		

Conclusion

Based on the present study it can be concluded that different doses of mycorrhiza and method of inoculation had differential effect on growth, yield and quality parameters of greenhouse tomato var. Pusa Ruby when grown under polyhouse. During the study, 500 sporocarps of mycorrhiza (*Glomus mosseae*) per kg of soil when inoculated through soil mix method gave maximum growth, yield, mycorrhiza colonization and mycorrhiza inoculation effect in greenhouse tomato *var.* Pusa Ruby and thus it may be recommended to enhance sustainable greenhouse tomato production.

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