

Full Length Research Paper

Tomato (*Lycopersicon esculentum* Mill.) growth in response to salinity and inoculation with native and introduced strains of mycorrhizal fungi

Hadad M.A¹, H.S. Al-Hashmi², Mirghani S.M.¹

¹Sudan University of Science and Technology, Shambat

²Agricultural Research Center, P.O.Box 50, P.C.121, Ministry of Agriculture and Fisheries Sultanate of Oman

Accepted 03 April, 2012

This work was carried out to investigate the effect of alien and indigenous strains of mycorrhizal fungi on two tomato cultivars recommended for economical production in Oman under greenhouse conditions. Three levels of phosphorus were added with and without mycorrhiza in a greenhouse experiment using sweet and brackish water (EC= 0.8 and 4 dS/m, respectively). Upon harvest (two and a half months from sowing), the data collected included number of branches, shoot and root weights, number and weight of fruits, tissue phosphorus, and nitrogen. Differences were encountered between the two cultivars as to their response to treatments. The addition of Omani mycorrhiza greatly enhanced plant growth traits in the Donato cultivar. Tissue P was increased which is reflected in the number and weight of the tomato fruits. The salinity effect was minimal probably because of the use of cultivars selected for high water salinity by the research center.

Keywords: Native, Inoculation, Arbuscular mycorrhiza, *Glomus moseae*, salinity *Lycopersicon esculentum*.

INTRODUCTION

Soils in Oman are generally sandy in texture and are known to be infertile; deficient in nitrogen and phosphorus. Available phosphorus ranges between 1.4-5.9 µg/g soil. Such P level is unsatisfactory for healthy growth of crop plants (Parkash, 1989). Omani soils also are calcareous in nature and tend to adsorb the added phosphate fertilizer and render it unavailable (Soil survey Report, 1996). High percentages amounting to 23-76% of the added orthophosphate fertilizer were found to be fixed in the Batinah soils (MAF, 1991). Also, no response was obtained when 450 kg of orthophosphate were added to three perennial grasses at Wadi Qriat research station (Parkash, 1988). Omani soils, also are often subject to secondary salinization resulting from highly saline irrigation water and from inorganic fertilizer additions.

Vesicular-arbuscular mycorrhizal fungi (VAM) are shown to have beneficial implications for plant survival (Ruth et al., 1996; Poss et al., 1985). Hirrel and Gerdemann (1980) also reported their effect on herbaceous plant growth enhancement. In surveying the occurrence of mycorrhiza in desert, arid and semi-arid regions, Gupta and Mukerji (2000) found that most plant taxa form associations with many mycorrhizal fungi. In a survey for mycorrhizal associations in Oman, Hadad and Al-Hashmi (1999) confirmed the existence of mycorrhizal association with Rhodes grass (*Rhodes Guyana*). And date palm, and vegetables.

Tomato is one of the crops, which received attention on mycorrhizal inoculation in other parts of the world. Different species of arbuscular mycorrhizal fungi (AMF) were found to infect the roots of tomatoes and produce resting spores in the rhizosphere soil (Azcon, et al., 1989; Edathil et al., 1994). Positive inoculation response was found when plants were inoculated under

*Corresponding author e-mail: muhanad1@hotmail.com

Table 1. Chemical and Physical properties of the soils used as a growth medium in the pot experiment

Soil property	Value
EC(DS/m)	2.6
pH	7.3
Soil Texture	Silt Loam
N(%)	0.03
Available P (mg/kg)	36.0
ExchangeableK (meq/l)	4.6
Exchangeable Na (meq/L)	3.7
Organic matter (%)	0.9
SAR	2

low and medium salt stress conditions (Alkaraki, 2000).

The status of mycorrhizal fungi was never explored in Omani soils which support the growth of many economical crops of which tomato represent a priority among vegetable crops. The availability of indigenous AMF, the response to inoculation with exotic AMF, and the effect of salt stress on such practice need to be investigated.

This work was therefore conducted to gain insight into the role which could be played by introducing alien strains of VAM as compared to inoculation with indigenous mycorrhizal fungi isolated from the rhizosphere of rhodes grass on tomato plants grown under low and medium salt stressed conditions.

MATERIALS AND METHODS

Two tomato cultivar seeds (Tatoo and Donato, obtained from the horticultural laboratory at ARC (Plant Production Research Center), Rumais were sown in a mixture of peat and perlite for 21 days. The seedlings of two cultivars were transplanted in pots (0.7m² area) containing 8 kgs of a sandy soil chosen with low E.C (Table 1). The soils were steam-sterilized twice for 2 h at 121°C with a week interval between sterilization cycles. The plastic pots to where the soils were transferred were disinfected with 95% ethanol. Two concentrations of superphosphate, which are normally applied by Omani farmers, were used to establish two levels of soil phosphorus. The initial P level in the soil used was 36 mg/kg. The pots were arranged in a completely randomized design in a greenhouse with weekly rerandomization .

The treatments used included two species of the genus *Glomus*; namely *Glomus mosseae* and *Glomus agrigigatal* (obtained from Japan), an extract from the

rhizosphere of Omani soil under rhodes grass known to contain mycorrhiza, two levels of inorganic phosphate, and a control treatment without inoculation.

Ten grams of the introduced mycorrhiza were added per pot. For Omani mycorrhiza, one Kg of a rhizosphere soil under Rhodes grass containing mycorrhiza (Hadad and Al-Hashmi, 1999, unpublished work), was sieved through a 100- μ m sieve. One liter of sterile water was added and agitated to make a uniform mixture. Ten mls were aseptically added to each pot designated for the Omani VAM treatments. A basal dose of N and K fertilizers were calculated and added to all the pots as per the research center recommendations under Omani conditions i.e. 500 kg of urea and 50 kg of potassium sulfate /ha. Nitrogen was added as urea and was split into three doses during the growing period (1.4 g/pot for each split). Two levels of inorganic phosphate were added to the inoculated pots i.e. 50 and 250 mg/kg soil. One hundred mls of sweet water (0.8 dS/m) were added to each pot to evenly distribute the added inoculum.

Each treatment was replicated three times in a split plot design. The pots were weekly re-randomized. Pots were kept in a shade. The plants were irrigated every three days with sweet water during the initial stages of growth to allow seed germination. Irrigation with saline water (EC=4 dS/m) started after 17 days from transplanting. The plants were covered with a net (agryl) for protection against white flies as recommended by the research center. The growth continued for two and a half-month starting from transplanting. During harvest, roots were gently washed to remove soil particles and cut from the shoots at ground level. Roots were uniformly blotted with water absorbent paper towel, and root fresh weights were recorded. Observations were taken on fresh and dry weight of shoots and roots, shoot/root ratio, number of

Table 2. The effect of alien and indigenous VAM and mineral phosphate additions on the shoot/root ratio of two tomato cultivars as influenced by water salinity

<i>Treatments</i>	<i>Tatoo cultivar</i>		<i>Donato cultivar</i>	
	S1	S2	S1	S2
Control	7.486	8.52	7.338	4.64
M(Ja) + P1	6.782	6.447	6.494	6.17
M(Ja) + P2	5.309	7.239	8.674	5.828
M(Jb) + P1	7.962	5.787	6.349	5.18
M(Jb) + P2	7.521	9.602	7.333	5.081
M(O) + P1	5.392	6.087	7.323	5.556
M(O) + P2	7.796	8.19	6.077	4.368
P1	8.282	9.565	6.291	6.338
P2	8.521	8.659	6.264	5.072

LSD(0.05) =3.158

Table 3. The effect of alien and indigenous VAM and mineral phosphate additions on the shoot dry weight of two tomato cultivarsAs influenced by water salinity

<i>Treatments</i>	<i>Tatoo cultivar</i>		<i>Donato cultivar</i>	
	S1	S2	S1	S2
Control	53.83	42.23	57.97	46.23
M(Ja) + P1	51.93	49.10	65.77	58.87
M(Ja) + P2	73.70	56.20	74.27	59.53
M(Jb) + P1	65.00	47.57	64.73	57.73
M(Jb) + P2	69.50	66.73	74.00	67.47
M(O) + P1	54.73	46.73	76.73	58.90
M(O) + P2	63.87	63.10	73.20	62.70
P1	74.97	51.93	66.73	59.70
P2	68.47	54.60	71.53	57.13

fruits, weight of fruits, tissue nitrogen and phosphorus. MSTAT was used for statistical analysis

RESULTS AND DISCUSSIONS

The data are presented in tables (1-8).

The addition of mineral phosphorus at both levels outyielded other treatments including the control treatment in S/R ratio. However, the Omani mycorrhiza with the low level of phosphate and the Japanese mycorrhiza with the high phosphate added gave the lowest S/R ratio with the Tatoo cultivar at the lowest salinity level used. This might indicate a relative efficiency in enhancing root weight. The data regarding both cultivars at different salinity levels is erratic, except for the apparent finding that in the Donato cultivar at the

higher salinity level, all treatments outyielded the control, which may indicate a positive effect of all treatments in increasing plant shoot weight.(table 2).

Regarding shoot dry weight, both the Japanese mycorrhiza when added with the higher level of mineral phosphate and the addition of mineral phosphate at the higher level consistently increased shoot dry weight in the Tatoo cultivar at both salinity levels(table 3).

The increase in root weight upon addition of treatments was variable (table 4). Both the Japanese mycorrhiza(a) when added with the higher phosphate level and the Omani mycorrhiza when added with the lower phosphate level increased root weight in the Tatoo cultivar at the lower salinity level. Moreover, the Japanese mycorrhiza at P1 increased root weight at the second salinity level(S2). With the Donato cultivar, however, the Omani mycorrhiza when added with P2

Table 4. The effect of alien and indigenous VAM and mineral phosphate additions on the fruit weight of two tomato cultivars as influenced by water salinity

Treatments	Variety 1		Variety 2	
	S1	S2	S1	S2
Control	389.7	299.1	225.3	300.8
M(Ja) + P1	358.8	321.6	390.9	269.3
M(Ja) + P2	418.2	387.1	398.8	360.5
M(Jb) + P1	433.2	359.5	404.4	263.8
M(Jb) + P2	389.5	387.5	388.5	376.1
M(O) + P1	311.5	294.8	418.5	330.8
M(O) + P2	171.6	301.1	434.3	275.0
P1	362.4	319.6	272.6	330.0
P2	376.4	330.3	438.6	330.0

LSD(0.05) = 140.1

Table 5. The effect of alien and indigenous VAM and mineral phosphate additions on the root dry weight of two tomato cultivars as influenced by water salinity

Treatments	Tatoo cultivar		Donato cultivar	
	S1	S2	S1	S2
Control	7.249	5.439	7.880	10.120
M(Ja) + P1	7.474	7.838	12.400	10.210
M(Ja) + P2	13.450	8.059	8.649	9.989
M(Jb) + P1	8.455	8.303	10.490	11.800
M(Jb) + P2	9.244	7.563	10.250	13.780
M(O) + P1	10.070	7.857	10.670	10.910
M(O) + P2	7.977	7.880	12.920	14.640
P1	8.804	6.119	11.270	10.810
P2	8.343	7.358	12.240	11.400

LSD (0.05)= 4.841

was superior at both salinity levels. Addition of mineral phosphorus at the higher concentration was comparable to both the addition of Omani mycorrhiza at P2 and the Japanese mycorrhiza at P1.

The addition of mineral phosphate at the lower level and the mycorrhiza from Japan at the higher phosphate level were superior to other treatments at the first salinity level (S1) in the Tatoo cultivar in increasing shoot phosphorus level. The data are consistent with the findings of Al-Karaki (2000), who inoculated tomato in a greenhouse in soils with low P. They reported an increase in shoot and dry matter yields in mycorrhizal plants. Also, they noted an increase in the accumulation of P in inoculated plants under both medium and low salt stress conditions. The effect of the Japanese mycorrhiza(b) was further extended at S2 in the Tatoo cultivar. In the Donato cultivar, however, both the Omani mycorrhiza at both levels of phosphate added

and the addition of mineral phosphorus outyielded all other treatments in increasing tissue phosphorus content (table 6). The number of branches was significantly increased upon addition of the Japanese mycorrhiza(b) with the low level of phosphorus to the Tatoo cultivar at S1. Also, Omani mycorrhiza at P1 showed a trend towards increasing the number of branches with the Tatoo cultivar at the lowest salinity level. The Japanese mycorrhiza when added with the higher level of phosphate gave the highest number of branches with the Donato cultivar at S2 level (table 7).

Although the data are erratic, a noticeable increase was evident in root weight upon application of Omani mycorrhiza with a low level of phosphate added. A similar increase was noticed upon application of the alien strains of mycorrhiza but when higher levels of mineral phosphorus were added. This may indicate a relatively higher efficiency of the Omani mycorrhiza.

Table 6. The effect of alien and indigenous VAM and mineral phosphate additions on the shoot phosphorus content of two tomato cultivars as influenced by water salinity

Treatments	Tatoo cultivar		Donato cultivar	
	S1	S2	S1	S2
Control	0.031a	0.048a	0.061a	0.119a
M(Ja) + P1	0.028a	0.054a	0.066a	0.074a
M(Ja) + P2	0.025a	0.051a	0.068a	0.092a
M(Jb) + P1	0.045a	0.058a	0.050a	0.076a
M(Jb) + P2	0.059a	0.062a	0.046a	0.090a
M(O) + P1	0.012a	0.044a	0.103a	0.089a
M(O) + P2	0.006a	0.052a	0.105a	0.090a
P1	0.053a	0.043a	0.103a	0.092a
P2	0.037a	0.053a	0.122a	0.092a

Table 7. The effect of alien and indigenous VAM and mineral phosphate additions on the number of branches of two tomato cultivars as influenced by water salinity

Treatments	Tatoo cultivar		Donato cultivar	
	S1	S2	S1	S2
Control	16.33 b	17.67b	16.33b	18.33b
M(Ja) + P1	15.00 b	18.00b	18.33b	17.67b
M(Ja) + P2	13.33 b	18.33b	16.00b	18.67b
M(Jb) + P1	43.33 a	16.33 b	16.00b	17.33b
M(Jb) + P2	16.67 b	15.67 b	16.67b	19.33b
M(O) + P1	22.00 b	17.67 b	17.67b	16.67b
M(O) + P2	17.67b	16.00 b	15.00b	18.33b
P1	15.67 b	18.33b	15.00b	17.67b
P2	16.67 b	16.00 b	17.67b	18.00b

LSD (0.05) = 13.74

(Table 5). The alien mycorrhizal strains consistently showed a trend towards increasing the fruit numbers, fruit weight and number of branches per plant (tables 3,4, and 7). The highest level of shoot phosphorus content however was obtained upon application of mineral phosphorus

For the cultivar effect, however, the response of the two tomato cultivars to the applied treatments was variable. While the Tatoo cultivar showed no apparent response to the added treatments, the Donato cultivar gave a positive response. All treatments with the Donato cultivar outyielded the control treatment in fruit number, fruit weight, and phosphorus content and in the number of branches. The Omani mycorrhiza gave the highest fruit number and relatively high shoot phosphorus content. A similar trend was noted with the number of branches with the alien mycorrhiza being superior to both the Omani mycorrhiza and the mineral

phosphate additions at both levels.

The higher salinity level (4.0 DS/m) reduced the shoot dry weight of both cultivars. Similarly, the root dry weight of the Tatoo cultivar was consistently reduced, which was not reflected with the data obtained with the Donato cultivar. The shoot phosphorus content tended to increase at the low salinity level applied (0.8 dS/m) to the Tatoo cultivar. The data, however was erratic regarding the Donato cultivar. Olsen et al.,(1999) used 5 levels of P ranging from 0, 9.2, 27.5, 82.5, 248 mg/kg soil. He found higher P concentration in leaf tissue with mycorrhizal plants grown in low P soils. The increase in dry matter was restricted to zero level phosphate. In an other study Olsen et al (1996) reported no differences in dry matter yield between inoculated and noninoculated plants despite the finding that inoculated plants had higher P concentration in their leaf tissue. However, at higher P concentrations, lower dry matter values were

Table 8. The effect of alien and indigenous VAM and mineral phosphate additions on the fruit number of two tomato cultivars as influenced by water salinity

Treatments	Tatoo cultivar		Donato cultivar	
	S1	S2	S1	S2
Control	10.670	8.000	5.000	4.000
M(Ja) + P1	10.330	8.333	7.333	7.000
M(Ja) + P2	11.000	8.333	6.000	7.333
M(Jb) + P1	9.333	10.000	6.667	6.000
M(Jb) + P2	12.330	10.330	7.667	6.667
M(O) + P1	9.667	9.000	7.333	7.000
M(O) + P2	9.000	9.667	7.333	7.333
P1	11.670	7.667	6.333	7.333
P2	9.333	11.000	9.000	7.000

obtained compared to uninoculated plants. This was related to the percent colonization. In this study, root colonization was not estimated. This may have shed light on the many discrepancies obtained with the different treatments and their interactions. In an other study, Olsen (1996) found that at the highest phosphate level added (248 mg/kg soil), the root length percentage colonized was only 2.4% when compared with the lowest phosphate added (9 mg/kg soil). Future studies should also look into mycorrhizal dependency.

REFERENCES

- Alkaraki GN (2000a). Growth of mycorrhizal tomatoes and mineral acquisition under salt stress. *Mycorrhiza*. 10(2): 51-54.
- Azcon R (1989). Selective interactions between free-living rhizosphere bacteria and vesicular-arbuscular mycorrhizal fungi. *Soil Biol. Biochem.* 21:639-644.
- Edathil TT, Manian S, Udaiyan K (1994). The effect of vesicular-arbuscular exposure period in the colonization and spore production in tomato seedlings (*Lycopersicon esculentum* Mill.), and on host biomass. *Agriculture Ecosystems and Environment*. 51: 287-292.
- Gupta R, Mukerji KG (2000). The growth of VAM fungi under stress conditions. In *Mycorrhizal Biology*. Mukerji, K.G., B.P. Gharrda, and S. tagjit (edit). Kluwer Academic/Plenum Publishers, New York.
- Hadad MA, Al-Hashimi HS (1999). A survey of mycorrhizal fungi in Omani Soils. *Agricultural Research Annual Report*. MAF, Sultanate of Oman.
- Hirrel MC, Gerdemann JW (1980). Improved growth of onion and bell pepper in saline soils by two vesicular-arbuscular mycorrhizal fungi. *Soil Sci. Soc. Ame. J.* 44:654-655.
- Olsen JK, Schafer JT, Edwards DG, Hunter MN, Galea VJ, Muller LM (1999). Effects of mycorrhizae established from an existing intact hyphal network on the growth response of *Capsicum* (*Capsicum annum* L.) and tomato (*Lycopersicon esculentum* Mill.) to five rates of applied phosphorus. *Australian J. Agric. Res.* 50 (2): 223-237.
- Parkash K (1989). Fertilization of rhodes grass (*Rhodes gyana*) in Oman. *Annual Research Report*. MAF Publications, Sultanate of Oman.
- Poss IA, Pond E, Menge IA, Horrel WM (1985). Effects of salinity on mycorrhizal onion and tomato in soil with and without additional phosphate. *Plant and Soil*. 88:307-319.
- Ruiz-Lozano JM, Azcon R (2000). Symbiotic efficiency and infectivity of an autochthonous arbuscular mycorrhizal *Glomus* spp. From saline soils and *Glomus desertica* under salinity. *Mycorrhiza* 10(3): 137-143.
- Soil survey Report, South Batinah Integrated Studies, Ministry of Agriculture and Fisheries (MAF). 1996.. Sultanate of Oman.