

Original Research Article

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Efficacy of *Entrophospora* sp. (VA Mycorrhiza) on Salt Tolerance and Flower Yield and Quality of Chrysanthemum var. Marigold [*Dendranthema grandiflora* Tzvelev.]

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ABSTRACT

Salinity of soil is a serious problem affecting plant growth and is increasing steadily in many parts of the world, particularly in arid and semi-arid areas. *Vesicular Arbuscular mycorrhiza* (VAM) is the most wide spread and significant mutualistic fungi having universal in their association including plants of agricultural and horticulture importance. VAM fungi have been shown to promote plant growth flower yield and salinity tolerance by various mechanisms. The effects of inoculation with *Entrophospora* sp. have been investigated on chrysanthemum var. Marigold, an important flower crop grown with four different levels of saline irrigation water (1.15 (control), 2, 4 and 6 dS/m). Plant flower yield and quality parameters and tolerance of the plants to salinity were determined. The results indicated that the *Entrophospora* sp. fungi could infect and colonize the roots effectively under high salinity levels were significantly enhanced flowering and yield parameters in the inoculated plants. However no flowering was seen in uninoculated plants at higher salinity levels of 6 dS/m levels. VAM association significantly increased tolerance of plants to salinity and was found as an effective measure to enhance establishment of the plant and to decrease soil salinity.

Keywords

Salt tolerance,
Yield, Quality,
Flower, Marigold.

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Introduction

Chrysanthemum (*Dendranthema grandiflora* Tzvelev.) is leading commercial flower crop grown for cut, loose flowers and pot plants. It ranks second in the international cut flower trade. In India, it occupies a place of pride, both as commercial flower crop and as a popular exhibition flower. The major use of chrysanthemum in our country is for making garlands, *veni*, bracelets and for religious offering. Chrysanthemums have been successfully bred into a wide variety of colors, shape and textures, making them the flower of choice for the mass market bouquet

business (Winogron, 1999). Increased flower production, quality of flowers and perfection in the forms of plants are important objectives to be recorded in commercial flower production. Salinity is one of the major abiotic stresses in crop production.

This problem is especially serious in arid and semi-arid regions (Heyward and Bernstein, 1990). The response of crop plants to saline water depends on the salinity levels as well as the resistance of the plants to salt stress (Wahome, 2004). These responses are highly

due to osmotic effects, which lead to growth disruption occasioned by reduced water uptake as well as reduced water potential in the soil, which lead to physiological stress. In addition, salinity can lead to accumulation of toxic ions in plant tissues. On the other hand, it can antagonize uptake of essential nutrients, e.g. chloride ions cause reduction in nitrate uptake, while sodium ion causes reduction in potassium uptake, hence inducing deficiencies of ions (Suarez and Grieve, 2011; Wahome, 2004).

Plants vary in their tolerance to irrigation with saline water. Irrigating plants with water of salinity higher than the plant can tolerate will result in yield loss and may decrease crop quality (Department of Agriculture and Food, 2004). Vesicular arbuscular mycorrhiza (VAM) fungi enhance the sink capacity of the root system and thus in turn, increase the photosynthetic performance of the plant leading to improved growth (Miranda *et al.*, 2011). Plants inoculated with VAM maintain relatively higher water content compared to uninoculated plants (Colla *et al.*, 2008; Sheng *et al.*, 2008). This is facilitated by the improved hydraulic conductivity of the root at low water potential (Kapoor *et al.*, 2008). The improved root conductance is associated with a longer root and an altered root system morphology induced by VAM (Dehne, 1982, Kothari *et al.*, 1990). Giri *et al.*, (2003) Reported to counter balance the adverse effects of salinity stress and thereby increase the plant growth. Keeping these in view, the present investigations were carried out, to know the impact of AM fungus *Entrophospora* sp. on yield of Chrysanthemum var. Marigold under saline condition.

Materials and Methods

The experiment was conducted using two factorial complete randomized design With *Entrophospora* sp. (VA Mycorrhizal) and

without *Entrophospora* sp. combination with four concentration of NaCl (1.15 (control), 2, 4 and 6 dS/m). These eight treatments were replicated 3 time (each row contain 8 pot plants) to give a total of 192 pots.

The data in all the experiments was statistically analysed by the method of analysis of variance as per Panse and Sukhatme (1989) and square root transformation of rare events were done as given by George and William (1994). Plants were grown under shade house condition. At the Kittur Rani Channamma College of Horticulture, Arabhavi. University of Horticultural Sciences, Bagalkot, Karnataka, India.

Chrysanthemum var. Marigold plants, moderately salt tolerant crop. Chrysanthemum multiplication was done by using shoot tip cuttings from mother plants. Cuttings were prepared as basal 10-12 cm long cuttings, planted in coco peat with and without *Entrophospora* sp. inoculums.

One and half month old uniform rooted cuttings were transplanted to pots. Each pots have soil of 10 kg per pot with mixture contains soil and FYM in 3:1 ratio. After 75 days of transplanting, each treatment of mycorrhizal and non mycorrhizal plants was irrigated with an equal (1000 ml) volume of the corresponding NaCl at weekly intervals. Leaching was prevented by keeping the soil below the field capacity at all times.

Alternatively Groundnut cake and Neem cake extracts (100 ml) were used as additional supply of nutrients for plants growth at fortnight interval. Plants were harvested 6 month after transplanting.

Flowering parameter were recorded on the 5 marked plants from which Number of flowers per plant, Flower yield per plant and per hecter. Individual flower weight, Flower

diameter (at the point of maximum breadth), Shelf life (loss in total flower weight hourly and counting the number of days taken) and available nitrogen (Subbaih and Asija, 1956), Available phosphorous, (Watanable and Olsen, 1965) Available potassium (Jackson, 1973), Number of chlamyospores (Gerdemann and Nicolson, 1963) and Per cent root colonization (Phillips and Hayman, 1970) with respective author depicted procedure were used to determine the ion concentration and root colonization.

Results and Discussion

Flower yield parameter

Flower yield parameters (Table 1) like number of flower per plant, individual flower weight, flower yield per plant, flower yield per hector of mycorrhizal and non mycorrhizal chrysanthemum var. marigold plants were significantly reduced by increased NaCl concentration in the soil compared to the control treatments, reduction in flower yield due to salt stress were more pronounced in non mycorrhizal than mycorrhizal plants.

Improved flower yield parameters of chrysanthemum var. Marigold plants at all NaCl stress than control treatment. Interaction between salinity and mycorrhizal colonization were significant for all parameter.

Flower quality parameter

Flower diameter (Fig 1) and flower shelf life (Fig 2) of mycorrhizal and non mycorrhizal chrysanthemum var. Marigold plants were significantly reduced by increased NaCl concentration in the soil compared to the control treatments, reduction in flower diameter and shelf life due to salt stress were more pronounced in non mycorrhizal than mycorrhizal plants.

Mycorrhizal colonization and chlamyospore count

Mycorrhizal colonization levels (Hyphal growth (%), vesicles (%) and arbuscular development (%)) and chlamyospore count in root tissues of chrysanthemum var. Marigold plants were significantly affected by NaCl treatments.

Mycorrhizal colonization declined gradually with increased NaCl concentrations in the soil (Table 2).

However, no significant differences were observed in the development of hyphal growth (%) in root tissues between mycorrhizal plants grown under control and 2 dS/m NaCl treatments.

VAM fungal colonization was negligible in plant roots that were not inoculated with *Entrophospora* sp. Interactions between NaCl and mycorrhizal colonization and chlamyospore per 50 g of soil were significant for all levels of mycorrhizal colonization in root tissues of chrysanthemum var. marigold plants.

Nutrient contents

Increasing NaCl levels reduced P, N, K concentrations because increased Na and Cl uptake of nonmycorrhizal chrysanthemum var. Marigold plants. However, VAM inoculated chrysanthemum var. Marigold plants had higher absorption of available P, N, K, from soil than those of uninoculated plants in all NaCl treatments (Table 3). Such increases in nutrient contents in response to the mycorrhizal effects were increased with increasing NaCl concentration in the soil. Interactions between salinity and mycorrhizal colonization were significant for N, P and K absorption from soil to shoot part of chrysanthemum var. Marigold plants.

Table.1 Effect of *Entrophospora* sp. and salinity on flower yield parameter of chrysanthemum var. Marigold

Treatments	Diameter of flower (cm)	Number of flower per plant	Individual flower weight (g)	Flower yield per plant (g/plant)	Flower yield per hector (t/ha)
VAM effect					
M ₀	3.64(1.91)	7.51(2.59)	2.22(1.57)	22.28(4.2)	11.00(3.08)
M ₁	4.89(2.32)	11.78(3.47)	3.10(1.89)	37.44(6.04)	18.49(4.27)
S. Em±	0.02(0.003)	0.51(0.06)	0.04(0.006)	1.71(0.12)	0.85(0.09)
CD at 5%	0.06(0.01)*	1.52(0.20)	0.11(0.02)	5.14(0.39)	2.54(0.27)
Salt levels					
S ₀	5.12(2.37)	13.96(3.76)	3.43(1.98)	48.57(6.90)	23.99(4.87)
S ₁	4.98(2.34)	10.44(3.30)	3.09(1.89)	32.44(5.72)	16.02(4.05)
S ₂	4.66(2.27)	9.64(3.18)	2.73(1.79)	26.25(5.16)	12.96(3.66)
S ₃	2.30(1.48)	4.54(1.89)	1.38(1.25)	12.20(2.84)	6.02(2.12)
S. Em±	0.03(0.003)	0.72(0.08)	0.05(0.01)	2.42(0.16)	1.20(0.12)
CD at 5%	0.08(0.01)	2.15(0.28)	0.15(0.04)	7.26(0.55)	3.59(0.38)
Interaction effect					
M ₀ S ₀	5.04(2.35)	10.75(3.32)	3.25(1.93)	34.80(5.90)	17.19(4.17)
M ₀ S ₁	4.92(2.32)	9.78(3.19)	2.97(1.86)	29.05(5.42)	14.35(3.84)
M ₀ S ₂	4.62(2.26)	9.50(3.16)	2.65(1.77)	25.28(4.07)	12.48(3.60)
M ₀ S ₃	0.00(0.70)	0.00(0.70)	0.00(0.70)	0.00(0.70)	0.00(0.70)
M ₁ S ₀	5.21(2.38)	17.17(4.19)	3.61(2.02)	62.34(7.90)	30.78(5.57)
M ₁ S ₁	5.04(2.38)	11.11(3.40)	3.22(1.92)	35.83(6.02)	17.70(4.26)
M ₁ S ₂	4.70(2.35)	9.78(3.20)	2.82(1.82)	27.21(5.26)	13.44(3.73)
M ₁ S ₃	4.59(2.28)	9.08(3.09)	2.75(1.80)	24.39(4.98)	12.05(3.53)
S. Em±	0.04(0.006)	1.02(0.13)	0.07(0.01)	3.43(0.25)	1.69(0.24)
CD at 5%	0.11(0.02)	3.04(0.40)	0.22(0.05)	10.27(0.78)	5.07(0.76)

M₀- Without *Entrophospora* sp. (VA Mycorrhiza) M₁- With *Entrophospora* sp. (VA Mycorrhiza)

S₀ - Normal water (1.15 dS/m) S₁- 2 dS/m S₂- 4 dS/m S₃- 6 dS/m

Table.2 Effect of *Entrophospora* sp. and salinity on mycorrhizal root colonization and chlamyospore count of chrysanthemum var. Marigold

Treatments	Root colonization (%)			Chlamyospore /50 g soil
	Hyphal growth	Vesicles	Arbuscules	
VAM effect				
M₀	16.92	10.25	7.42	28.90
M₁	87.92	78.58	77.00	255.37
S. Em±	0.74	0.89	0.64	2.14
CD at 5%	2.22	2.67	1.91	6.41
Salt levels				
S₀	56.50	48.83	46.83	193.20
S₁	54.00	45.17	44.50	153.47
S₂	51.33	43.83	40.67	130.10
S₃	47.83	39.83	36.83	91.77
S. Em±	1.05	1.26	0.90	3.02
CD at 5%	3.14	3.77	2.70	9.07
Interaction effect				
M₀S₀	18.33	11.00	9.33	32.67
M₀S₁	17.67	10.33	9.33	32.20
M₀S₂	16.33	10.33	7.00	28.53
M₀S₃	15.33	9.33	4.00	22.20
M₁S₀	94.67	86.67	84.33	353.73
M₁S₁	90.33	80.00	79.67	274.73
M₁S₂	86.33	77.33	74.33	231.67
M₁S₃	80.33	70.33	69.67	161.33
S. Em±	1.48	1.78	1.27	4.28
CD at 5%	4.44	5.33	3.82	12.82

M₀- Without *Entrophospora* sp. (VA Mycorrhiza) M₁- With *Entrophospora* sp. (VA Mycorrhiza)
 S₀- Normal water (1.15 dS/m) S₁- 2 dS/m S₂- 4 dS/m S₃- 6 dS/m

Table.3 Effect of *Entrophospora* sp. and salinity on available nutrient absorption from soil by chrysanthemum var. Marigold

Treatments	N (kg/ha)	P (kg/ha)	K (kg/ha)
VAM effect			
M ₀	94.34	81.04	828.84
M ₁	62.01	72.16	733.31
S. Em±	0.10	0.08	0.08
CD at 5%	0.31	0.23	0.24
Salt levels			
S ₀	111.55	69.74	843.29
S ₁	69.10	81.57	822.63
S ₂	63.00	78.04	611.23
S ₃	69.05	77.05	847.15
S. Em±	0.15	0.11	0.11
CD at 5%	0.44	0.33	0.34
Interaction effect			
M ₀ S ₀	163.54	74.76	923.03
M ₀ S ₁	78.60	87.55	924.67
M ₀ S ₂	72.45	81.39	533.83
M ₀ S ₃	62.75	80.46	933.81
M ₁ S ₀	59.57	64.73	763.54
M ₁ S ₁	59.60	75.59	720.60
M ₁ S ₂	53.54	74.69	688.63
M ₁ S ₃	75.34	73.63	760.48
S. Em±	0.21	0.16	0.16
CD at 5%	0.62	0.47	0.49

M₀- Without *Entrophospora* sp. (VA Mycorrhiza) M₁- With *Entrophospora* sp. (VA Mycorrhiza)
 S₀ - Normal water (1.15 dS/m) S₁- 2 dS/m S₂- 4 dS/m S₃- 6 dS/m

Fig.1 Effect of *Entrophospora* sp. and salinity on flower shelf life of chrysanthemum var. Marigold. M₀: without *Entrophospora* sp. M₁: with *Entrophospora* sp.

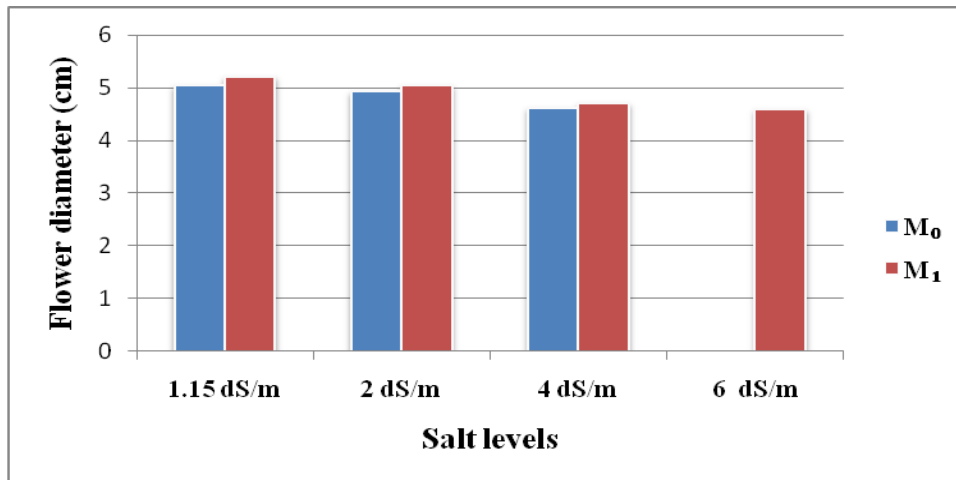
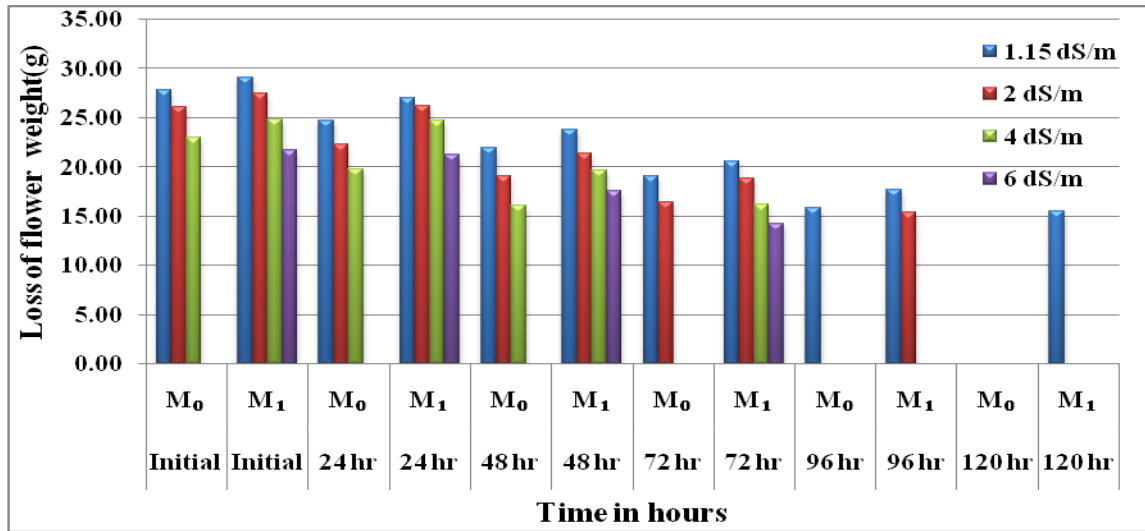


Fig.2 Effect of *Entrophospora* sp. and salinity on flower shelf life of chrysanthemum var. Marigold. M₀: without *Entrophospora* sp. M₁: with *Entrophospora* sp.



Flower yield of chrysanthemum var. Marigold plants was significantly reduced by increasing salt concentration in the soil compared to the control plants. A number of other researchers have reported similar effects of salinity in reducing yield for a range of other horticultural and flower crops (Manjunath, 2000, Belew *et al.*, 2010). Mycorrhizal colonization significantly improved yield and plant tolerance to salt stress of chrysanthemum var. Marigold plants grown at high salinity. VA mycorrhizal colonization increase nutrient acquisition of salt-stressed chrysanthemum var. Marigold plants (Belew *et al.*, 2010). In salt stress soils, the extensive hyphae network of the AM fungus explores more soil volume and increases the absorption surface of roots (Sanders and Tinker, 1973), thus contributing to the enhanced P concentration in mycorrhizal plants, while non-mycorrhizal plants lack this benefit. Increased mean flower weight, which would result in the formation of higher sink capacity by retention of more number of flowers (Johnson, 1984).

Shelf life extension in flowers may be due to effectiveness in controlling the weight loss,

which might be due to reduced rate of respiration and transpiration from flower surfaces (Rao and Chundawat, 1991). The decrease in the respiration could be further attributed to lowering of succinate and malate dehydrogenase activities associated with TCA cycle (Mehta *et al.*, 1986). Diameter of the flower increased but it decreased with increased salinity because uptake of available nutrient from soil was more in mycorrhiza inoculated withput salt treated plants but uptake was decreased with increased salinity may be the effect to decreased flower diameter of chrysanthemum var. marigold flower.

The present study demonstrated that the levels of mycorrhizal colonization in chrysanthemum var. Marigold root decreased with increasing NaCl concentrations in the soil. The results obtained here are in agreement with earlier reports that addition of salt to soil inhibits VAM colonization by inhibiting the germination of spores, decreasing growth of hyphae after infection had occurred and reducing the arbuscules and vesicles per cent Belew *et al.*, (2010). However, in spite of the decrease in VAM

colonization, the increase in growth, biomass and flower yield of chrysanthemum var. Marigold plants resulting in *Entrophospora* sp. inoculation indicates that the beneficial effects of VAM fungi on plant growth and flower yield.

Enhancement of growth in mycorrhizal plants in saline conditions has been related partially to Mycorrhizal mediated enhancement of host plant P nutrition (Shrinivas, 1998; Jacobs, 1979). Interestingly, mycorrhizal chrysanthemum var. Marigold plants had higher P, N, K contents than non-mycorrhizal plants at salt stress treatments. It is evident from the study that plant tolerance to salt stress was improved greatly by AM fungal colonization. We suggest that better growth and biomass in mycorrhizal kalanchoe plants is an indication of enhanced tolerance to salt stress and is a manifest of improved uptake of nutrients and maintaining favourable ionic ratios than non-mycorrhizal plants (Belew *et al.*, 2010).

Use of *Entrophospora* sp. VA mycorrhizal fungus enhances flower yield and quality parameter of Chrysanthemum var. Marigold. Through enhancing nutritional status, water uptake by increasing the mycorrhizal root colonization. All growth of the plant was found to be significant at control salinity and 2 dS/m salinity level. No flowerings were observed at 4 dS/m salinity level in nonmycorrhizal plants but flowering observed in mycorrhiza treated plants.

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