Research Article

Growth and Flowering Response of Marigold (*Tagetes erecta*) to Salt Stress

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Abstract | Salt stress is major concerns to agriculture globally. Salt stress interferes enzymatic activities and several physiological processes that lead to reduction in crop yield and quality. The current investigation was performed at Horticulture Garden where two marigold cultivars (V_1 = African orange and V_2= Dwarf double mix) were subjected to salinity stress condition (0, 2, 4, 6 and 8 dS m^{-1}). The results exhibited that salt stress revealed adverse effect on all the parameters of both of the varieties of marigold. The plants irrigated with canal water (control) having EC of 0.7 dSm^{-1} showed better results for both seed and flowering related traits. The plants treated with canal water showed better seed germination (82.56 %), seed germination index (2.04), plant height (21.31 cm), branches/plant (45.61), leaves/plant (201.67), flowers/plant (8.56), diameter of flower (7.95 cm), fresh root biomass (0.821 g) and dry root biomass (2.28 mg). The plants treated with 2 dSm^{-1} showed seed germination (65.35 %), seed germination index (1.53), plant height (16.61cm), branches/plant (40.38), leaves/plant (195.33), flowers/plant (6.83), diameter of flower (6.75 cm), fresh root biomass (0.718 g) and dry root biomass (2.04 mg). It was further noted that as the salt stress increases the plant performance for all investigated traits decreased significantly. The varieties showed highly different responses for both seed and flowering related attributes. The variety dwarf double mix had a better seed germination and flowering growth and production in comparison with African orange. The double mix showed better seed germination (64.64 %), seed germination index (1.53), plant height (14.94 cm), branches/plant (36.71), leaves/plant (190.73), flowers/plant (5.64), diameter of flower (6.32 cm), fresh root biomass (0.660 g) and dry root biomass (2.12 mg). It is concluded that salt stress up to 0.7 dSm^{-1} did not reveal any adverse effects on germination and flowering response of marigold. The salinity at 2, 6 and 8 dSm^{-1} caused simultaneous adverse effects on all the studied parameters.

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Introduction

Marigold (*Tageteserecta* L.) is herbaceous annual plant belongs to the family Asteraceae (Kumar *et al*., 2016). Marigold is used both for ornamental and medicinal purposes. It is also used in cosmetic and perfume industry due to its aromatic nature and essential oil contents (Regaswamy and Koilpillai, 2014). Marigold is a major seasonal flowering plant grown in the public parks, gardens, and roadside

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throughout the year. Most of the species of marigold have dark green leaves with attractive yellow, deep orange and white colored flowers. The African marigold is comparatively taller than French marigold (Valdez-Aguilar *et al*., 2009). Several genotypes of both the species are generally used as container and bedding plants for landscape purpose (Mlcek and Rop, 2011). It has also been observed that some species of African marigold are used as cut flowers and sold in markets for making garlands. Marigold is very popular among flowers because of its adaptability under diverse environmental and saline conditions (Mlcek and Rop, 2011). The importance of marigold in the pharmaceutical and cosmetic industries is also well documented (Hussain *et al*., 2008).

Salinity is major concerns to agriculture globally (Munns, 2002; Chrysargyris *et al*., 2018; Munns and Tester, 2008). Salt stress interferes enzymatic activities and several physiological processes that lead to reduction in crop yield and quality (Carter and Grieve, 2008; Friedman *et al*., 2010; Grieve *et al*., 2005; Shillo *et al*., 2002) The toxicity produced by certain ions including Na+ and Cl- due to their concentrations in large quantity in soil and water under saline conditions (Escalona *et al*. 2012; Arancon *et al*. 2008) Salts tress adversely affects the cell growth and development due to accumulation of several toxic compounds outside the plant roots that eventually provided unfavorable conditions for plant growth and development (Villarino and Mattson, 2011) It is reported that salinity adversely influences the 45 million hectares of the irrigated land (Mlcek and Rop, 2011) Available reports also reveal that salt stress conditions also affecting the agricultural land of Asia, accounting 50 % yield losses of the crops by the mid of 21st century. Several lines of evidence indicate that some species of ornamental plants can be successfully grown under moderate salts stress environment without reduction in economically acceptable yield (Munns and Tester, 2008) The importance of the marigold in floriculture industry is well known (Kumar *et al*., 2016, Villarino and Mattson, 2011) Nevertheless, very limited researched about flowering effect on marigold to salinization conditions (Grattan and Grieve, 1999). Hence, the seed germination, growth and flowering behavior of marigold under salt stress environment needs to be assessed critically. Keeping in view the adverse effect of salt stress, the study was performed to investigate the seed germination, development and blossoming response of marigold cultivars against salt stress.

Materials and Methods

The current investigation was done at Horticulture Garden where two marigold cultivars (V_1 = African orange and V_2= Dwarf double mix) were subjected to salt stress condition (0, 2, 4, 6 and 8 dS m^{-1}). Completely randomized design was constructed to observe different parameters related to marigold. Salt stress levels were prepared using NaCl and distilled water H_2O. Seeds were sown in 8 inch clay pot containing canal silt. Seeds were watched daily for water requirement. Irrigation was applied after 2 days interval.

Data recording methodology

Seed germination: Seed germination was recorded by applying following formula

$$Seed\ grtminsyion\ \% = \frac{\text{Number of germinated seed}}{\text{Total number of seed}} \times 100$$

Seed index:

$$Seed\ index = \frac{\text{Germinated seed}}{\text{Before count}} \times \frac{\text{Germinated seed}}{\text{After count}}$$

Plant height: plant height was measured from bottom to top with measuring tape.

Number of leaves, branches and flowers plant–^{1}

The number of leaves, branches and flowers were counted visually at the end of experiment from randomly three plants of each treatment.

Flower diameter: The flower diameter was measured with vernier caliper.

Fresh root biomass (g): Fresh root biomass was measured with the help of digital weighing balance by randomly selected three plants from each treatment. The roots were washed thoroughly with tap water and spread on tissue paper to drain out excess water for three hours. After that roots were weighted.

Dry root biomass (g): After recording data of fresh biomass roots were dried at room temperature for 3 to 4 days. Then data of Dry root biomass was measured with the help of digital weighing balance by randomly selected three plants from each treatment.

Data analysis

Data was analyzed by using statistical analysis software Statistix 8.1 (Statistix, 2006). In order to compare treatment superiority and performance, the least significant variance (LSD) assessment was practical at 0.05% possibility equal.

Results and Discussion

Seed germination (%)

Results pertaining to seed germination presented in Table 1 showed significant effect of salt stress. The better germination (82.56 %) was recorded where seeds were sown by applying canal water (control) whose EC was 0.7dSm^{-1}. Among the salinity treatments, the better result for seed germination (65.35 %) was observed where salinity treatment was decreased 8 dS.m^{-1} to 2 dS.m^{-1}. The increasing salinity treatment 8 dS.m^{-1}showed germination 50.00 %. Among the varieties African orange and Dwarf double mix had statistically significant but results were similar in both varieties (64.64 and 64.12 %), respectively. The interaction showed that Dwarf double mix variety under control produced maximum seed germination (83.27).

Table 1: *Consequence of salinization on sprouting of seed % of marigold.*

Salt stress Treatments	Varieties		Mean
	African Orange	Dwarf double mix	
T_1 = Control	81.78 b	83.27 a	82.56 A
T_2 = 2 dSm^{-1}	65.10 c	65.60 c	65.35 B
T_3 = 4 dSm^{-1}	62.26 d	62.10 de	62.18 C
T_4 = dSm^{-1}	57.43 e	62.267 d	59.85 D
T_5 = dSm^{-1}	50.00 f	50.00 f	50.00 E
Mean	63.31 B	64.64 A	
	Varieties (V)	Salt Stress (S)	V X S
SE	0.1602	0.2534	0.35833
P value	0.0000	0.0044	0.0342
LSD 0.05	0.3367	0.5323	0.7528

Seed germination index

Table 2 shows that seed germination index had statistically significant results for treatments and varieties. The maximum seed germination index (2.04) was recorded in control. However, the increasing rate of saline water concentration decreased the germination. The average result (1.53) was observed where 2 dS. m^{-1} saline concentration was applied. The 8 dS.m^{-1} produced lowest germination index 1.18. The varieties shows statistical significant result, where dwarf double mix produced maximum result 1.53 and the minimum result was observed in African orange (1.51). As far as result regarding interaction showed that Dwarf double mix variety under control produced maximum seed germination index (2.05).

Table 2: *Salinization effect on seed index of marigold.*

Salt stress Treatments	Varieties		Mean
	African Orange	Dwarf double mix	
T_1 = Control	2.01 b	2.05 a	2.04 A
T_2 = 2 dSm^{-1}	1.51 d	1.54 c	1.53 B
T_3 = 4 dSm^{-1}	1.41 f	1.43 e	1.42 D
T_4 = dSm^{-1}	1.44 e	1.44 e	1.45 C
T_5 = dSm^{-1}	1.18 g	1.18 g	1.18 E
Mean	1.51 B	1.53 A	
	Varieties (V)	Salt Stress (S)	V X S
SE	6.9030	4.3663	9.7633
P value	0.0000	0.0005	0.0171
LSD 0.05	0.4145	9.1933	0.32205

Table 3: *Effect of salt stress on plant height (cm) marigold.*

Salt stress levels	Varieties		Mean
	African Orange	Dwarf double mix	
T_1 = Control	20.46 a	22.17 a	21.31 A
T_2 = 2 dSm^{-1}	16.13 b	17.11 b	16.61 B
T_3 = 4 dSm^{-1}	13.17 cd	14.24 c	13.70 C
T_4 = dSm^{-1}	11.16 e	12.16 de	11.67 D
T_5 = dSm^{-1}	8.50 f	9.05 f	8.75 E
Mean	13.89 B	14.94 A	
	Varieties (V)	Salt Stress (S)	V X S
SE	0.3625	0.5731	0.8105
P value	0.0091	0.0000	0.9022
LSD 0.05	0.7616	1.2041	1.7029

Plant height (cm)

Result pertaining to plant height (Table 3) showed statistically significant results for treatment and varieties. The interaction of treatment and varieties was also significant. Plant height increased when saline levels was decreased. Plant height ranges from 8.75 cm to 21.31 cm. Maximum height of plant was noted under control. Whereas the lowest plant height (8.75 cm) was observed under 8 dS m^{-1}. The saline water at 2 dS m^{-1} produced average plant height (16.61 cm). On the basis of varieties Dwarf double mix produced highest plant height (14.94 cm) as compare to African orange. As far as result regarding interaction showed that Dwarf double mix variety under control produced maximum plant height (22.17 cm).

Branches per plant

Table 4 presented result for branches per plant treated with salt stress. The dwarf double mix variety performed better result for number of branches as compared to African orange variety. The maximum branches (36.71) was evaluate in dwarf double mix whereas minimum number of branches plant^{-1} (32.33) was observed in African orange. The salt stress had also significant affect for number of branches plant^{-1}, the maximum branches (45.61) was recorded under control. Increasing the salt stress level effect on branches (40.38) recorded under 2 dS.m^{-1}. However, the minimum number of branches (22.44) was recorded with increased the saline level at 8 dS m^{-1}. As far as result regarding interaction showed that Dwarf double mix variety under control produced maximum number of branches plant^{-1} (47.12).

Table 4: *Salt stress on branches of marigold.*

Salt stress Treatments	Varieties		Mean
	African Orange	Dwarf double mix	
T_1 = Control	44.12 b	47.12 a	45.61 A
T_2 = 2 dSm^{-1}	38.78 c	42.00 b	40.38 B
T_3 = 4 dSm^{-1}	33.34 e	35.67 d	34.50 C
T_4 = dSm^{-1}	28.45 f	30.89 e	29.67 D
T_5 = dSm^{-1}	17.00 h	27.89 g	22.44 E
Mean	32.33 B	36.71 A	
	Varieties (V)	Salt Stress (S)	V X S
SE	0.6114	0.9667	1.3671
P value	0.0000	0.0000	0.0012
LSD 0.05	1.2844	2.0309	2.9721

Leaves plant–1

In Table 5 presented various result for branches in plant treated with salt stress. The dwarf double mix variety performed better result for leaves per plant than to African orange variety. The maximum leaves per plant (190.73) was in dwarf double mix variety whereas minimum leaves plant^{-1} (187.87) was observed in African orange. The salt stress had also significant affect for leaves plant^{-1}, the maximum leaves (201.67) was recorded under control. Increasing the salt stress level effect on number of leaves (195.33) recorded under 2 dS/m. However, the minimum number of leaves (177.61) was recorded with increased the saline level at 8 dS.m^{-1}. As far as result regarding interaction showed that Dwarf double mix variety under control produced maximum leaves plant^{-1} (203.00).

Table 5: *Salinization stress on leaves of marigold.*

Salt stress Treatments	Varieties		Mean
	African Orange	Dwarf double mix	
T_1 = Control	200.33 b	203.00 a	201.67 A
T_2 = 2 dSm^{-1}	193.67 d	197.00 c	195.33 B
T_3 = 4 dSm^{-1}	187.11 f	190.44 e	188.78 C
T_4 = dSm^{-1}	181.67 h	184.56 g	183.11 D
T_5 = dSm^{-1}	176.56 j	178.67 j	177.61 E
Mean	187.87 B	190.73 A	
	Varieties (V)	Salt Stress (S)	V X S
SE	0.2184	0.2504	0.3541
P value	0.0000	0.0000	0.0000
LSD 0.05	0.3327	0.5260	0.7439

Table 6: *Impact of salt stress on flowers of marigold.*

Salt stress Treatments	Varieties		Mean
	African Orange	Dwarf double mix	
T_1 = Control	8.22 a	8.88 a	8.56 A
T_2 = 2 dSm^{-1}	7.00 b	6.67 b	6.83 B
T_3 = 4 dSm^{-1}	5.00 c	5.22 c	5.11 C
T_4 = dSm^{-1}	3.44 e	4.22 d	3.83 D
T_5 = dSm^{-1}	2.00 g	3.22 f	2.61 E
Mean	5.13 B	5.64 A	
	Varieties (V)	Salt Stress (S)	V X S
SE	0.1925	0.2252	0.3185
P value	0.0000	0.0000	0.0295
LSD 0.05	0.2993	0.4732	0.6692

Flowers plant–1

The salt stress varieties resulted significantly effect for number of flowers (Table 6). Maximum flowers were observed under control (8.56), followed by 2dS.m^{-1} resulted 6.83, respectively. Whereas the minimum number of flowers (3.61) was recorded under 8dS/m. On the basis of varieties dwarf double mix variety produced number of flowers plant^{-1} (5.84). The African orange produced (5.33) number of flowers plant^{-1}. As far as result regarding interaction showed that Dwarf double mix variety under control produced maximum number of flowers plant^{-1} (8.88).

Flower diameter

The effect of salt stress was also highly significant for flower diameter (cm) (Table 7). The maximum flower diameter (7.95cm) was observed under Control. Results on saline water application showed that the marigold produced maximum flower diameter (6.75 cm) under 2 dS.m^{-1}. Whereas, the increasing rate decreased the flower diameter. The minimum flower diameter (4.75 cm) was observed under 8 dS.m^{-1}. Among the varieties dwarf double performed better results for flower diameter (6.53 cm). However, the minimum flower diameter (5.52 cm) was recorded under African orange. As far as result regarding interaction showed that Dwarf double mix variety under control produced maximum flower diameter (8.47cm).

Table 7: *Salt stress on flower diameter (cm) of marigold.*

Treatments	Varieties		Mean
	African Orange	Dwarf double mix	
T_1 = Control	7.43 b	8.47 a	7.95 A
T_2 = 2 dSm^{-1}	6.17 e	7.33 b	6.75 B
T_3 = 4 dSm^{-1}	5.30 d	6.30 c	5.80 C
T_4 = dSm^{-1}	4.25 g	5.30 d	4.77 D
T_5 = dSm^{-1}	3.50 f	4.20 h	3.85 E
Mean	5.33 B	6.32 A	
	Varieties (V)	Salt Stress (S)	V X S
SE	0.4184	0.2766	0.3183
P value	0.0000	0.0000	0.0924
LSD 0.05	0.2018	0.2609	0.2275

Table 8: *Effect of salt stress on fresh root biomass (g) of marigold.*

Salt stress Treatments	Varieties		Mean
	African Orange	Dwarf double mix	
T_1 = Control	0.803 b	0.840 a	0.821 A
T_2 = 2 dSm^{-1}	0.706 d	0.730 c	0.718 B
T_3 = 4 dSm^{-1}	0.650 f	0.680 e	0.665 C
T_4 = dSm^{-1}	0.530 h	0.550 g	0.540 D
T_5 = dSm^{-1}	0.470 j	0.500 i	0.485 E
Mean	0.632 B	0.660 B	
	Varieties (V)	Salt Stress (S)	V X S
SE	6.9030	4.3663	9.7633
P value	0.0000	0.0000	0.0000
LSD 0.05	0.4145	9.11933	0.3220

Fresh root biomass (g)

Salt stress level had statistically significant variance for the fresh root biomass (g) (Table 8). The result indicates that maximum fresh root weight was noted (0.827 g) under control. However, increasing of salt stress levels decreased fresh weight of biomass 0.718 to 0.485 g. The maximum fresh root biomass (0.718 g) was noted from increasing level 2 dS.m^{-1}. Whereas the minimum fresh root biomass (0.485 g) was observed from 8 dS.m^{-1}. Among the mean of verities dwarf double mix produced maximum fresh root biomass (0.660 g) as compared to African orange (0.632 g). As far as result regarding interaction showed that Dwarf double mix variety under control produced maximum fresh root biomass (0.840 g).

Dry root biomass (mg)

Result for dry root biomass (mg) in Table 9 had significant variance of salt stress for dry root biomass. The result showed that Dwarf double mix produced maximum dry root biomass (2.12 mg) under control. Whereas African orange produced minimum dry root biomass (1.94 mg). Among the salt stress dry root biomass decreased 2.36 to 1.65 mg. The maximum dry root biomass (2.36 mg) was observed under control. Further result indicates the increasing levels of salt stress 8 dS.m^{-1} decreased the dry root biomass (1.65 mg). As far as result regarding interaction showed that Dwarf double mix variety under control produced maximum dry root biomass (2.57 mg).

Table 9: *Effect of salt stress on dry root biomass (mg) of marigold.*

Salt stress Treatments	Varieties		Mean
	African Orange	Dwarf double mix	
T_1 = Control	2.13 c	2.57 a	2.36 A
T_2 = 2 dSm^{-1}	2.20 c	2.35 b	2.28 B
T_3 = 4 dSm^{-1}	1.95 d	2.13 c	2.04 C
T_4 = dSm^{-1}	1.80 e	1.84 e	1.82 D
T_5 = dSm^{-1}	1.62 f	1.68 f	1.65 E
Mean	1.94 B	2.12 A	
	Varieties (V)	Salt Stress (S)	V X S
SE	0.0153	0.0242	0.0342
P value	0.0000	0.0000	0.0146
LSD 0.05	0.0321	0.0508	0.0718

The adverse effect of salts to crop production has been recognized since long ago and several studies have been conducted on salt stress tolerance of diverse crop species. In this study salt stress environment reveals negative effect on all the traits. The seed germination and germination index were negatively influenced by saline conditions. There was an inverse effect of salinity on the seed germination and with increasing salinity level, the seed germination and index decreased considerably (Tanveer *et al.*, 2013). This might due to less uptake of water by seeds resultantly few seeds were germinated. (Torbaghan, 2012). Also reported that under saline conditions the seed germination ate decreased significantly. In this study height of plant, flowers per plant, flower diameter & leaves per plant

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was also affected by salt stress treatments. Munns and Tester reported that salt stress environment affect the growth and development of plants for two possible reason. Firstly, the accumulation of excess salt in the soil and water solution significantly decreases the water uptake efficiency of plant. Secondly, the large quantity of salts injures the cell while entering in the transpiring stream that eventually leads to reduced photosynthetic rate, growth and development of plants. Among cultivars, double mix had better results for most of the parameters. This might be due to genetic potential of cultivar to sustain the adverse impact of salt stress conditions.

The salt stress environment also induced decrease vegetative part of the plants. This might be due to adverse impact of salinity on enzymatic activities in plants that leads to defect metabolism. Moreover, high osmotic pressure resulted from salt stress conditions restricted cell of plant to uptake water and certain mineral nutrients effectively (Cicek and Cakirlar, 2002). (Kaouther *et al*., 2012) reported that the fresh biomass decreased significantly with increasing salinity. Results pertaining to fresh root biomass was relatively higher for marigold genotypes that were treated only canal water. Root is one of the most important parameters that highly affect the water and nutrient uptake efficiency of plants (Kasukabe *et al*., 2004). In the current study, heavier roots under control (canal irrigation water) might have been associated with osmotic adjustments of plants that got mechanism for required cell division and enlargement thus showed better fresh root production (Kaya *et al*., 2006) On the contrary poor root production under saline water conditions might be due to the failure of the plants to avoid dehydration of water.

Conclusion and Recommendations

It is concluded that salt stress up to 0.7 dSm^{-1} did not reveal any adverse effects on germination growth and flowering response of marigold. The salinity at 2, 6 and 8 $dS.m^{-1}$ caused simultaneous adverse effects on all the studied parameters. Both the varieties also did not show tolerance to salt stress. However, double mix had significantly better results in comparison with deep orange for all the traits.

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Novelty Statment

Marigold is salt stress up to 0.7 dSm^{-1} did not reveal any adverse effects on germination and flowering response of marigold. The salinity at 2, 6 and 8 dSm^{-1} caused simultaneous adverse effects on all the studied parameters.

Author's Contribution

Muzamil Farooque Jamali and Niaz Ahmed Wahocho: Conducted field research and set the paper.
Tanveer Fatima Miano and Fayaz Ali Jamali: Supervised the research study.
Tanveer Fatima Miano, Khalid Hussain Talpur and Niaz Ahmed Wahocho: Provided technical inputs.
Zulfiqar Ali Abbasi and Muhammad Iqbal Jakhro: Helped in revised manuscript and gave final shape for publication.
Sohail Ahmed Otho: Helped in seedbed preparation and cultural practices.

Conflict of interest

The authors have declared no conflict of interest.

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