IRRIGATION AND SALINITY EFFECTS ON SOME MORPHO-PHYSIOLOGICAL CHARACTERISTICS IN GERMAN AND ROMAN CHAMOMILE POPULATIONS

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To evaluate the effect of salinity on some morpho-physiological characteristics in German and Roman chamomile in Yazd province, Iran, the experimental plan were used. The treatments consisted of four salinity levels of the irrigation water (6, 9, and 12 dS m^{-1}) and 2 German and Roman chamomile populations. A field examination was conducted using randomized Split-Plot statistical designs with 4 replications. The seedlings were planted in nursery then transplanted in early April in 2014 and 2016 to the main land. Salinity treatments were applied by weekly irrigation after transplanting. In this study plant height, number of flowers per plant, shoot, root and flower weight fresh and dried, flower essential oil weights, leaf relative water content, leaf relative water loss and 1,000 seed weight were investigated. The results of the current study showed that the Tehran population in most characteristics was the best. The result showed that there were no difference in fresh and dry weight of flower and essential oil weight among populations. Data showed that except for root fresh and dry weight, plant height and 100 seed weight, other traits were higher significantly at first year. All traits were highest in control Ec. In this study by increasing salinity levels, morphological traits showed a different trend. In conclusion we could demonstrate that using different levels of salinity had significant effects on some morpho-physiological characteristics in Roman chamomile. In this study the German population had the highest essential oil. According to the effect of salinity on the above mentioned characteristics, the German and Roman chamomile cultivation can be recommended by 9 dS m^{-1}.

Keywords: chamomile, morpho-physiological characteristics, population, irrigation, salinity, Yazd.

INTRODUCTION

Iran displays mostly arid and semi-arid areas and water availability is a major problem in crop production. Fifteen percent of total agricultural lands of Yazd have salt in water or soil. Soil salinity is one of the worldwide problems adversely affecting the agricultural production (Levitt, 1980). Salinity is a major environmental stress and is more conspicuous in arid and semi-arid areas where 25% of the irrigated lands are influenced by salts (Al-Khateeb, 2006). Salt stress and soil salinity create ionic and osmotic stress on many plants. Also, ionic toxicity generated

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from salt contaminated soil has negative effects on plant growth and development (Munns *et al*., 2006).There are many defense mechanisms in plants which are tolerant to water-deficit and salt stresses, such as osmoregulation, ion homeostasis, antioxidant and hormonal systems (Mahajan and Tuteja, 2005), helping plants to survive and grow under severe environmental conditions prior to their reproductive stages. The defense mechanisms in sensitive plant species are weaker, leading to growth retardation and yield reduction. Biochemical and physiological parameters in plants cultivated in salt conditions have been developed as effective indices for tolerant screening in plant breeding programs (Ashraf and Foolad, 2007). Salinity adversely affects the process of germination, seedling establishment, plant growth and yield in almost all the cultivated crops by lowering the osmotic potential of water in the growing medium or by causing specific ionic toxicity or both. Salinity has been reported to affect adversely the composition of photosynthetic pigments and the changes in pigment composition depend upon the specific nature of ion, plant species and the age of plant (Levitt, 1980). The anatomical and morphological features typical of halophytes are usually considered to be adaptations to salinity. There is very little experimental evidence to show whether the same features occur when the halophytes are not exposed to the effects of salinity.

Chamomile is one of the most popular herbs in the Western world. There are two plants known as chamomile: the more popular German chamomile (*Matricaria recutita*) and Roman, or English, chamomile (*Chamaemelum nobile*). Although they belong to different species, they are used to treat the same health problems. Both are used to calm frayed nerves, to treat stomach problems, to relieve muscle spasms, and to treat skin conditions and mild infections (Bewley and Black, 1982 and Singh *et al*., 2011).

Matricaria recutita L. (syn. M. chamomilla L., Chamomilla recutita L. Rauschert) is known as true chamomile or German chamomile. German chamomile does not have scale-like pallets between the flowers of the capitulum. Capitulum is bottoming cone-shaped long and hollow.

Fig. 1. German (left) and Roman Chamomile (right).

This plant has white ligulate flowers, smells pleasantly of chamomile – typical chamomile smell – and is annual, growing 10 to 80 cm high. The plant has thin spindle shaped roots. The stem is in an upright position, mostly heavily ramified, bare, round, and filled with marrow. The leaves are alternate, double to triple pinnatipartite, with narrow-linear prickly pointed sections being hardly 0.5 mm wide. The golden yellow tubular florets with five teeth are 1.5 to 2.5 mm long, ending always in a glandulous tube. The white ligulate flowers are 6 to 11 mm long and 3.5 mm wide (Franke, 2005). The name of this plant is derived from Greek word *chamos* which means 'ground', and *melos* which means 'apple'. These words refer to slowness of growing and apple odor of fresh flowers of the chamomile (Sharrif moghaddasi, 2011). The Latin name of recruits refers to the petals, meaning truncated, trimmed (Franke, 2005). The chamomile has varieties of diploid 2n=18 and tetraploid 2n=36. The varieties of diploid have shorter growth and less brushwood height than the varieties of tetraploid (Sharrif moghaddasi, 2011). It may be considered as an economic substitute for field crops irrigated with fresh water since it has adaptability to wide range of climate and soil (Abari *et al*., 2011). The areas becoming unsuitable for conventional crops may be used for growing such plants depending upon their suitability to the prevailing environmental condition. The performance of chamomile on saline water has not been well studied or documented and there are only a few reports on the effect of water salinity on morphological characters and oil composition of chamomile (Afzali *et al*., 2006). The aim of this study was to determine the effect of different levels of salinity on some morpho-physiological characteristics in Roman chamomile cultivated in Yazd, Iran.

MATERIAL AND METHODS

The present experiment was carried out the during 2014–2016. The soil properties of the location are presented in Table 1.

Table 1

Soil chemical characteristics of experimental field

EC (dS/m)	5.2
pH	7.7
Cl (MEq/L)	22.8
S.Anions	28.9
Mg + Ca (MEq/L)	49
Na (MEq/L)	22.5
S.Cations	68.4

Seeds were planted in the 2014 autumn cases and the seedlings were transplanted in early 2016 March. The selected populations for planting were pointed from the result of genetic diversity plan during the previous years. Several indices to measure each samples were selected randomly from the area and finally they were averaged. Each experimental plot size was 3 m × 4 m and in each plot, the plants were grown in three equidistant rows with adjacent rows being 30 cm apart. After transplanting the seedling from the nursery to the main land, salinity treatments were applied with weekly irrigation. The experimental treatments consisted of four salinity levels of the irrigation water (6, 9, and 12 dS m^{-1}) compared to the control (2 dS m^{-1}) and 2 chamomile populations (German and Roman) into the 4 replication plot. The salinity levels were obtained by addition of appropriate amount of Na-Cl to water and were adjusted by a portable EC meter instrument. The different irrigation treatments started at the beginning of transplanting after the start of their growth and development until harvest.

MORPHO-PHYSIOLOGICAL TRAITS

At full flowering stage, five plants were selected from the middle row by eliminating border effects. Then, the traits; no. of flowering stems, plant height (cm), capitol diameter of flowers, flowers and root weight (wet or dried), plant height, number of branches per plant, number of flowers per bushes, plant dry weight, number of flowering branches and essential oil weight were measured and investigated. The flowers were gradually harvested and weighted for the determination of fresh flower yield. Dry root and flower weight of each plot was calculated after drying the flowers at room temperature (21–24 at 8 °C). Plant height was measured by using a ruler with an accuracy of 1 mm of 5 plants and their averages were evaluated. The individual plant samples of each population were conditioned in plastic bags and transported to the laboratory under refrigeration. Samples (~200 g) were air dried at room temperature (21 to 24 °C) and maintained in a refrigerated chamber (10 °C) until extraction. Each sample used in this survey was deposited at the herbarium. The air-dried samples (100 g) were subject to water distillation for 2 h using a clevenger-type apparatus. The leaf relative water content (LRWC) was determined in the fully expanded topmost leaf of the main shoot. The fresh weight of the sample leaves was recorded and the leaves were immersed in distilled water in a Petri dish. After 2 h, the leaves were removed, the surface water was blotted-off and the turgid weight recorded. Samples were then dried in an oven at 70 °C to constant weight. Leaf relative water content was calculated using the following formula (Turner, 1981): LRWC (%) = [(F.W – D.W) / (T.W – D.W)] × 100

Whereas: F.W., Fresh weight; D.W., Dried weight; T.W., Turgid weight.

To determine the relative water loss (RWL), a sample of 5 fresh flag leaves were taken from each plot and FW was measured. The leaves were then wilted at 35 °C for 5 hrs and reweighed (W5H). Then the samples were oven-dried at 70 °C and weighed again (DW). RWL was calculated by the following formula (Farshadfar *et al*., 2001): RWL (%) = [(F.W – W5H) / (F.W – D.W)] × 100

Whereas: F.W., Fresh weight; W5H., The leaves were then wilted at 35 °C for 5 hrs and reweighed: D.W., Dried weight;

A field examination was conducted using randomized Split-Plot statistical designs with 4 replications at the experimental station of Yazd training center of agriculture. The main factors were different levels of salinity (6, 9 and 12 dS m^{-1}) and sub-factors were German and Roman selected genotypes in first and second years of cultivation period.

The statical model was as below

$$yijk = \mu + \alpha i + \beta j + (\alpha\beta)ij + cik + eijk$$

Whereas: μ is a population mean, αi is the main effect of soil type (A) i, i = 1, . . . , 3, P3 i=1 αi = 0, βj is a main effect of barley variety (B) j, j = 1, . . . , 4, P4 j=1 βj = 0, (αβ)ij is the interaction effect of A and B, Pi(αβ)ij = 0 for each j and Pj(αβ)ij = 0 for each I cik ∼ iid N(0, σa2) is the plot (pan) error distribution, k = 1, 2, eijk ∼ iid N (0, σe2) is the subplot (individual) error distribution, k = 1, 2.

Data were analyzed by analysis of variance using the SAS (2003) software program. The mean values were compared using the least significant difference test (LSD) and P value less than 0.05 was considered as significant.

RESULT AND DISCUSSION

The mean comparisons of some morpho-physiological traits of German and Roman Chamomiles due to salt stress are shown in Table 2. There were significant differences in trial groups. Fresh Shoot weight, root fresh and dry weights, Number of flowering branches and flowers per meter were at the highest amount in Tehran population compare to other ones. Except of root fresh and dry weight, plant height and 100 seed weight, other traits were higher significantly at first year. All traits were highest in control Ec. The amount of Fresh and dry shoot weight, Fresh and dry root weight, Essential oil weight and Number of flowering branches in plots that obtained water Ec = 9 dS m-1 were near them in control level. Fresh and dry flower weight, Number of flowers per plant, 1,000 seed weight and RWL were decreased significantly by increasing in salinity levels. Leaf relative water content (RWC) was in the highest and leaf relative loss (RWL) in the least amount in the Roman population.

Table 2

Salinity effect on some morpho-physiological traits in German and Roman Chamomile

Treatments	**Means**						
	Fresh shoot weight (g)	Dry shoot weight (g)	Fresh root weight (g)	Dry root weight (g)	Fresh flower weight (g/m^2)	Dry flower weight (g/m^2)	Number of flowers per plant
Genotypes							
German	27.83b	9.53	64.21[b]	12.08[b]	2014	1117	40.47[b*]
Roman	32.46a	10.38	77.88[a]	16.73[a]	1980	1089	48.22[a]
P-value	**	n.s	**	**	n.s	n.s	**

Table 2 (continued)

Year							
1	32.54[a]	17.11[a]	62.18[b]	13.77[b]	1980a	1528[a]	47.43[a]
2	29.07[b]	12.68[b]	83.56[a]	15.98[a]	1130b	692[b]	43.50[b]
P-value	**	**	**	**	**	**	**
EC							
6	25.47[c]	8.92[bc]	62.22[c]	13.61[c]	1307[ab]	1141[ab]	45.31[b]
9	30.86[b]	9.90[b]	78.00[b]	14.90[b]	1295[ab]	1130[ab]	40.52[bc]
12	38.92[b]	8.83[c]	66.27[c]	12.58[c]	1397[b]	1097[b]	38.34[c]
P-value	**	**	**	**	**	**	**

*Means within row with no common on letter are significantly different ($p \leq 0.05$).

Results revealed that flower essence weight was higher in the German population and the year of cultivation had no effect on weight of flower essence. Plant height was at the lowest when EC increased and it was at the highest in the German population.

Table 3

Salinity effect on some morpho-physiological traits in German and Roman

Treatments	Means						
	Essential oil weight (g)	Number of flowering branches	Flower head (capitulum) diameter (cm)	1,000 seed weight (kg)	Plant height (cm)	RWC	RWL
Genotypes							
German	0.380	22.15[b]	2.14	0.028[a]	31.82	63.83[b]	18.06[a]
Roman	0.316	26.25[a]	2.23	0.027[b]	30.83	60.72[c]	17.58[b]
P-value	n.s	**	n.s	**	n.s	**	**
Year							
1	0.345	36.22[a]	2.35[a]	0.027[b]	30.57[b]	63.29	17.61[a]
2	0.346	11.90[b]	1.98[b]	0.034[a]	32.77[a]	63.98	15.97[b]
P-value	n.s	**	**	**	**	n.s	**
EC							
6	0.305[b]	19.16[d]	2.19	0.028[a]	30.49[c]	61.73[b]	18.27[a]
9	0.377[a]	25.22[b]	2.14	0.027[b]	29.10[c]	63.56[b]	16.51[b]
12	0.314[b]	21.84[c]	2.19	0.026[b]	32.08[b]	64.87[a]	16.14[b]
P-value	**	**	n.s	**	**	**	n.s

*Means within row with no common on letter are significantly different ($p \leq 0.05$).

The result of 1,000 seed weight (kg), RWC and RWL are shown in Table 3. The result revealed from these data 1,000 seed weight (kg) was increased in second year. Additionally, different levels of salinity and genotypes could change it significantly. There were significant differences between experimental groups toward RWC and RWL. RWC was increased by salinity levels and RWL was decreased instead.

Data showed that there were significant differences in experimental groups about Shoot weight ($P \leq 0.05$). Additionally, there were significant differences between experimental groups by EC types ($P \leq 0.05$). Number of flowering branches, flowers capitol diameter and number of flowers per each plant were at the highest in German population ($P \leq 0.05$). Results of (Deepika *et al*., 2015) study indicated that increasing salinity from 0 to 150 mM decreased fresh weight of shoot (76.3%) and increased of root fresh weight (53.8%). They showed that oil content of air dried flowers remained almost unaffected up to 9 dSm-1 EC levels but thereafter it declined with increasing EC levels. They noted that this reduction in oil content was the highest under sulphate dominated salinity as compared to chloride dominated salinity. German chamomile appears to be a highly salt tolerant medicinal herb. Zeinali *et al*. (2008) investigated the regression model for dry flower yield as dependent variable and the other traits as independent in German chamomile. Results showed the traits days to 50% flowering, No. of flower plant-1 and plant height entered to model and accounted for 73, 8 and 3% of dry flower yield variation, respectively. The other research has reported the significant and positive relationship of the traits, no. of flower plant^{-1}, fresh flower yield, 100 flower weight, days to flowering and plant height with essence percent (Pirkhezri *et al*., 2008). Salt stress is a limiting factor of plant growth and yield, and is becoming a serious problem in the world (Chaum and Kirdmanee, 2009). Salinity which is produced by root cells plays a prominent role in various physiological processes such as plant growth, ion uptake, photosynthesis and germination (Hayat and Ahmad, 2007, Raskin, 1992). In the current study different types of salinity changed flowers head (capitulum) diameter and number of flowers per each plant significantly ($P \leq 0.05$). The results of (Mahdikhani *et al*. 2007) revealed that the high phenotypic variation for the traits biological yield, dry flower yield, number of flower plant^{-1} and essence percent. Omid (1999) showed the lower essence percent and kamazulene of the local varieties in comparison with the advanced cultivars. Pirkhezri *et al*. (2008) observed significant differences between chamomile genotypes for all the traits except stomata length. Zeinali *et al*. (2008) investigated the effect of the planting date in chamomile. They reported that on March increase in the traits no. of flower plant^{-1}, days to 50% flowering, dry flower yield and essence percent in comparison with 20 March and 5 April. Indeed, delay in planting and impact on flowering stage of temperatures above 23 °C cause floret infertility and finally flower yield deficiency. In (Ghanavati and Sengul, 2010) study there was a significant difference between genotypes studied for all traits except for root relative water content. In general, high NaCl concentrations produce water deficit, ion toxicity, nutrient imbalance and oxidative stress. These adverse effects cause modifications of root morphology and inhibition of plant growth and can result in plant death. Tolerance to abiotic stresses is associated with modifications of morphological and physiological traits (Edmeades *et al*., 2001). These results are highly inconsistent with findings of Cirecelav *et al*. (2008), Zeinali *et al*. (2008), Alexandra (2005) and Marinho (2006) on German chamomile genotypes and accessions. Ghanavati *et al*. (2011) showed from salt application trials indicated that dry matter yield was decreased with increasing NaCl doses. Pirzad *et al*. (2011) showed that leaf relative water content (LRWC), proline and total soluble sugar were not affected by irrigation levels. They showed that in their experimental condition, LRWC had no changes in range of our treatments. Despite being same, LRWC in all treatments were in high amounts, showing a high level maintenance of water in water deficit and excess water conditions. The rate of RWC in plants with high resistance against drought is higher than others. In other words, plant having higher yields under drought stress should have high RWC. Under water deficit, the cell membrane is subject to changes such as increase in penetrability and decrease in sustainability (Blokhina *et al*., 2003).

CONCLUSION

In this study we could demonstrate that using different levels of salinity had significant effects on some morpho-physiological characteristics in Roman Chamomile populations cultivated in Yazd. German populations in most characteristics were the best but despite the non significant difference, German population had the highest essential oil. By importance of salinity adverse effects on fresh and dry weight of flower and essential oil weight, the chamomile cultivation may be recommended till 9 dS m^{-1} water Ec. Further studies are needed to obtain more detailed explanation.

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