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Performance of Chrysanthemum or Chrysanthemum Morifolium Ramat (CV. Balady) in Different Saline Water Irrigated Soils and Growing Media

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ABSTRACT

As a result of the decreasing availability of high-quality irrigation water, the salinity tolerance of cut flowers is of increasing importance. The influence of salinity on the growth and quality of Chrysanthemum, Chrysanthemum morifolium L. grown in two different media under four salinity levels was evaluated. C. morifolium plants were grown in plastic pots containing either zeolitic tuff or soil as potting media. Seedlings of C. morifolium were subjected to four NaCl/CaCl2 salinity levels (2, 4, 6, and 8 dS.m-1). The effect of increasing salinity level on growth, flowering characteristics, time to flower, length and diameter of flowering shoots, and the diameter of the terminal flower on each stem were evaluated. On termination of the experiment, plant height, two perpendicular canopy widths, and fresh and dry weights of shoots were measured. Results indicated that most of all measured characteristics were reduced in response to increasing salinity levels. Increasing salinity levels caused significant reductions in plant height, fresh and dry yield, and relative water content. Moreover, salinity reduced flower quality (color, size, stem thickness, and length) and yield. Also, some physiological changes occur in stomatal conductance, leaf relative water content, and chlorophyll content. C. morifolium plants showed a good salinity resistance by irrigating plants with saline water up to 4 dS.m-1. Significant differences in C. morifolium plant responses were also detected between soil and zeolitic tuff media for most tested characteristics, in which using zeolitic tuff as rowing media was better to cope with higher salinity levels than plants grown in soil. In conclusion, it is recommended to use zeolitic tuff instead of soil when water salinity is a problem in irrigation water.

Keywords: Chrysanthemum, Chrysanthemum morifolium, salinity, growing media, zeolitic tuff, ornamental plants, Jordan.

INTRODUCTION

Growing cut-flowers became one of the important high-value agricultural industries worldwide. Chrysanthemum morifolium Ramat (Asteraceae) with a high ornamental value is the fourth most popular cut flower in the world; therefore this flower occupies a very important position in

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the world cut flower industry (Sun et al., 2010, 2011). C. morifolium is one of the long-lasting cut-flower and it has one of the largest flowers in the market. It can be propagated vegetatively either through root suckers or terminal cuttings (Shatnawi et al., 2010). It is estimated that there are more than 20,000 chrysanthemum cultivars in the world (Anderson, 2007). Japan was by far the largest producer with 2 billion stalks of C. morifolium, followed by the Netherlands (800 million), Colombia (600 million), and Italy (500 million). In 2016, the Ministry of Agriculture figures indicate that there are 3.33 million cut-flower seedlings in Jordan (Agricultural Statistics Bulletin, 2017).

Jordan now ranks as the world's second water-poorest country. Jordan is a semi-arid environment, and three-quarters of annual water demand goes for agricultural uses. Jordanian soil contains a high level of calcium carbonate, and low soil organic matter leading to nutrient deficiency (Owais *et al.,* 2013). Salinity is one of the major environmental factors limiting plant growth and development in Jordan, where rainfall is insufficient to leach salt.

As a result of the decreasing availability of high-quality irrigation water, the salinity tolerance of greenhouse crops is of increasing importance worldwide. Irrigation plants with saline water may have profound side effects on plant growth and development (Ashraf *et al*., 2008; Cassaniti *et al*., 2009). Nevertheless, a high salt level of salt in the root environment decreased the flower and stem quality of many plants (De Kreij and van den Berg, 1990). Furthermore, irrigation plants with saline water resulted in decreased plant height, shoot length, leaf area and dry weight (Chartzoulakis and Klapaki, 2000), flower plant yield (Cabrera, 2003), a delay of flowering (Van Zandt and Mopper, 2002), leaf elongation (Montesano and van Iersel, 2007), root and shoot dry weights (Al-Karaki, 2000; Montesano and van Iersel, 2007), and plant length, flower number per plant, flower and shoot length, fresh and dry weights (Aydinsakir *et al*., 2010). In addition, plants showed also some physiological and metabolic alterations primarily on photosynthesis rate, leaf conductance, chlorophyll fluorescence, and chlorophyll content (Chen *et al*., 2003a, b; Montesano and van Iersel, 2007; Zribi *et al.,* 2009; Niu and Cabrera, 2010).

One of the most important factors that play a key role in the quality production of cut-flowers in the potting/growing media. The good root medium must provide support for the plants, supply water, and nutrients, permit the gas exchange to and from the roots. This will lead to proper shoot and root growth (Yasmeen *et al*., 2012). Cassaniti *et al.* (2009) used a media mix of peat and perlite, while Bayat *et al.* (2012) used loam soil-sand-compost to test the ornamental plant's tolerance for salinity. Owais *et al.* (2013) noticed a growth reduction in plants grown in volcanic tuff. Natural zeolites are among the minerals that are used to develop new substrates for plant growth, they are used for seedling production, rooting of cuttings, and potting of ornamental plants (Manolov *et al*., 2005). Abdi *et al*. (2006) reported that zeolite reduces the leaching of ammonium and nitrate from the soil, and zeolite increased the rate of photosynthesis due to the availability of different elements and water for the plants. Volcanic tuff substrate holds promises for improving lily flower yield and quality (Al-Ajlounia and Othman, 2020). Safi *et al*. (2005) indicated that a higher carnation yield was obtained when the plants were grown in zeolitic tuff. Ramesh *et al*. (2011) found that using zeolites is better due to their unique physical and chemical properties including ion exchange, dehydration-rehydration, and adsorption properties made them useful in agricultural applications and environmental engineering as they were found to increase crop yield and to promote nutrient use efficiency.

Consequently, the Jordanian environmental conditions increase the interest to look for ornamental plants that tolerate high salinity levels in irrigation water. A better understanding of saline water’s effect on plant growth and physiology can help to improve cultivation with saline water and perhaps lead to the use of saline water as a growth retardant. Little information exists on salt tolerance of C. morifolium, thus, the objective of this study was to investigate the impact of irrigation C. morifolium with four saline water regimes (2, 4, 6, and 8 dS.m-1) in two growing media (soil and zeolitic tuff).

MATERIALS AND METHODS

Experimental plant materials and treatments

The experiments were set up under greenhouse conditions at the University of Jordan Campus, Amman, Jordan throughout the 2015/2016 growing season to determine the impact of different salt stress levels on several growths and physiological characteristics of C. morifolium plants. The C. morifolium cut flowers were obtained from a local nursery, in Amman, Jordan. Stem cuttings of C. morifolium were grown in 10 L pots containing two potting media; soil and zeolitic tuff in Med-October, 2015, and the plants were fertilized with NPK fertilizer (20: 20: 20) at End-October. The chemical properties of the volcanic tuff were 41.26% SiO_2, 12.41% Al_2O_3, 15.6% Fe_2O_3, 0.25% MnO, 2.86% TiO_2, 7.26% CaO, 1.94% K_2O, 0.63% P_2O_5, 7.82% MgO, 2.73% Na_2O, 7.24% LOI, and 2.96% Si (Almjadleh et al., 2014). The EC and the pH for the used soil taken before the experiment initiated were 0.41dS m–1 and 7.9, respectively (AL-Fraihat, 2015). Determination of relative water content (RWC) was done in March 2016. Stomata resistance was measured using a Porometer. All plants were allowed to establish for 1-2 weeks under well-irrigation with a complete nutrient solution before the initiation of saline treatments have been set up. Calculations, accounting for soil water holding capacity, leaching requirements, and intervals between irrigations were made to schedule irrigation amounts and frequencies.

Saline solutions were prepared by adding sodium chloride (NaCl) and calcium chloride ($CaCl_2$) at 85% and 15% (by weight), respectively, to the nutrient solution. Four levels of irrigation water salinity were used. The salinity levels were adjusted into 0 (control), 2, 4, 6, and 8 dS.m-1. Irrigation water pH was adjusted to 6.5-7.0. The C. morifolium plants were grown in either soil or zeolitic tuff and were subjected to the above-mentioned four salinity levels. There were 5 plants per each treatment (salinity level or growing media), which were randomly placed on greenhouse benches. To monitor salt accumulation in the root zone, leachate was collected from three potted plants treatment at 30 days post-treatment and once again at the end of the experiments. The EC and pH of leachate were determined using an EC and pH meter.

Growth and flower parameters

To quantify the effect of salt stress on C. morifolium flowering characteristics, time to flower, length and diameter of flowering shoots, and the diameter of the terminal flower on each stem were recorded. On termination of the experiment, plant height was recorded from the growing media level to the inflorescence' top at the flowering stage via a 200±0.05 cm ruler using five randomly selected plants/plot, and the average plant height was calculated. Five randomly selected plants were harvested/pot to measure fresh plant weight, and hereafter the plants were dried up at 70°C for 48 h for dry weight determination. At the flowering stage (February, 11th to March, 2nd, 2016), the following parameters were measured: plant height, DW, and fresh weight (FW) of the plants. Plant height (cm) was recorded from the growing media level to the top of inflorescence at the flowering stage via a 200±0.05 cm ruler, from five plants from each treatment, and then the average plant height was calculated. Five randomly selected plants were harvested from each treatment to measure fresh plant weight, and then the plants were dried at 70°C for 48 hours for dry plant weight determination. The effect of salinity on the vase life of flowering shoots was also measured in terms of relative loss of fresh weight (FW). Flowering shoots from selected salinity treatments were harvested and weighed in groups of three shoots. Then, one set of shoots, with three replications, was placed in an Erlenmeyer flask with a known volume of deionized water for rehydration, after which the relative FW (RFW) was recorded at 4, 7, 10, and 14 days. On termination of the experiment, when most of the flower heads are fully opened, shoots were severed at the substrate surface.

Flowers, leaves, and stems were washed in deionized water, blotted dry, placed in paper bags, and dried in an oven at 70°C to reach constant DW. Leaf, flower, and shoot DW were recorded.

Physiological parameters

Leaf greenness (or relative chlorophyll content) was measured using a handheld chlorophyll meter (measured as the optical density), SPAD reading for all plants on the leaf in the middle of the shoot at the end of the experiment for all survived plants on both fully expanded young and old leaves at the lower part of the shoot. Leaf chlorophyll fluorescence yield was measured on 3 days during the experiments on young, fully expanded leaves by using a Pulse-Modulated Fluor meter (OS1-FL modulated chlorophyll Fluor meter, ADC Bio Scientific Ltd., Hertford, UK). Stomata resistance values were measured using a Steady-State Porometer (AP4 model, Delta T Devices) attached to the side of leaves. Readings were recorded on three fully expanded leaves, situated at different positions of the canopy. Fully expanded fresh leaves were sampled from the leaves in the middle of the plant to determine relative water content (RWC). The fresh weight was measured after harvesting (Wf). The leaves were then floated on a Petri-dish filled with distilled water for 24 hrs in the dark, then weighed to obtain a fully turgid mass (Wt). After that, the leaves were dried at 70°C for 24 hrs and weighed to obtain the dry mass (Wd). The leaf RWC was calculated using the following equation according to Martinez et al. (2004); RWC = (Wf - Wd)/(Wt - Wd)*100.

Statistical analysis

The experimental treatments were a factorial experiment arranged in a Randomized Complete Block Design (RCBD) with five replications. The statistical analysis was performed using the Proc General Linear Model (GLM) (SPSS 19.0, SPSS Inc. Chicago, IL, USA) (SPSS, 1997). The data were analyzed using factorial analysis of variance (ANOVA) to detect the differences among the tested parameters (Zar, 1999). When significant differences were detected, means were separated using the Least Significant Differences (LSD) test at a probability level of 5% (0.05) (Abacus Concepts, 1991).

RESULTS

Effect of salinity and growing media on plant growth

Plant height, FW, and DW for C. morifolium plants grown at different salinity levels in soil and zeolitic tuff growing media are presented in Table 1. The C. morifolium plants grown in soil showed significant differences in height under different salinity levels. The tallest plants were noticed for C. morifolium grown in the control treatment. There were significant differences in plant height for plants grown in zeolitic tuff. Results demonstrated that increasing salinity level up to 8 dS.m-1 causes a significant reduction in plant height ranging between 24% and 40%. The effect of salinity was less pronounced under zeolitic tuff media. Similar results were observed for both total plant FW and DW (Table 1). Plants grown in the soil had the highest FW and DW under control treatment. However, this was significantly different from the FW of plants that were grown under EC of 2-8 dS·m-1. Moreover, results indicated that increasing salinity levels caused a significant reduction in FW and DW for plants grown in both types of media. Subjecting C. morifolium to a salinity level of 8 dS·m-1 resulted in a significant reduction in FW ranging from 26% to 24% when compared to the control treatment in soil and zeolitic tuff, respectively. While the reduction in DW was 35% for plants grown in soil and 61% for those grown in zeolitic tuff.

Table 1: Plant height (cm) and total plant fresh and dry weight (g/plant) for Chrysanthemum morifolium plants grown at different salinity levels in soil and zeolitic tuff growing media.

EC	**Plant height**		**Fresh weight**		**Dry weight**	
dS.m-1	Soil	Z. tuff	Soil	Z. tuff	Soil	Z. tuff
0	113.75a	96.00a	196.8a	130.6a	66.6a	51.8a
2	106.50b	85.50b	183.2b	121.2b	58.9b	46.7ab
4	95.00c	82.75bc	179.2b	112.5c	55.3c	40.4b
6	87.25d	79.38c	164.5c	107.6c	50.9d	32.9c
8	68.50e	73.13d	144.1d	98.9d	42.9e	20.1d

Values in the same factors and column with different letters are statistically different ($p<0.05$)

Effects of salinity and growing media on flower production and quality

Results indicated that increasing salinity resulted in a delay in flowering in C. morifolium plants as compared to the control treatment (Table 2). The highest number of days to flowering was obtained when salinity level was the highest in irrigation water in both soil and zeolitic tuff growing media. C. morifolium started flowering after 131.8 days in the control treatment and it was delayed by about 26 days once growing it under 8 dS.m-1 in both soil and zeolitic tuff. No significant differences were observed between plants grown in zeolitic tuff and soil. Flower FW and DW were also affected by salinity treatments (Table 2). The results demonstrated that C. morifolium grown in soil has the highest FW (55.6 g) as compared to 48.3 g for plants grown in zeolitic tuff under control treatment. Increasing salinity level from 2 up to 8 dS.m-1 caused a significant reduction in flower FW at all salinity levels. Each increase in salinity level has resulted in a significant reduction in plant height, FW, and DW. As compared to the control treatment, the reduction reached 58% for plants grown in zeolitic tuff and 48% for plants grown in soil. A similar trend of results was observed for the effect of salinity on flower DW (Table 2). A significant reduction in flowers DW ranged from 48% to 77% in plants grown at 8 dS.m-1 in soil and zeolitic tuff, respectively.

Table 2: Days to flowering and flower fresh and dry weight (g/plant) for Chrysanthemum morifolium plants grown at different salinity levels in soil and zeolitic tuff growing media.

EC	**Days to flowering**		**Fresh weight**		**Dry weight**	
dS.m-1	Soil	Z. tuff	Soil	Z. tuff	Soil	Z. tuff
0	131.8d	131.5e	55.6a	48.3a	9.1a	8.6a
2	141.5c	139.0d	47.3b	43.5b	7.9ab	6.1b
4	147.0b	145.3c	41.3c	39.9c	7.4b	4.6c
6	151.3b	152.0b	38.0c	30.9d	6.9b	3.9c
8	157.8a	158.3a	28.5d	20.4e	4.7c	2.0d

Values in the same factors and column with different letters are statistically different ($p<0.05$)

Flower length, diameter and number of inflorescences for C. morifolium plants grown at different salinity levels in soil and zeolitic tuff growing media are shown in Table 3. The number of inflorescences for plants grown in soil and zeolitic tuff was not significantly different under different salinity levels used in the experiments except for plants grown at EC of 8 dS.m-1. The number of inflorescences was reduced once using soil up to 40% comparing the control treatment to the EC 8 dS.m-1, the reduction reached 37% once using zeolitic tuff (Table 3). As a general trend, flower length was decreased as salinity level in irrigation water increased in both soil and zeolitic tuff. Flower length ranged from 19.2 cm to 12.8 cm, and from 20.4 cm to 13.0 cm in response to increasing salinity level from control up to 8 dS.m-1 once grown in soil and zeolitic tuff, respectively. Although, 33% to 36% reductions in flower length were observed in both soil and zeolitic tuff in response to salinity, no significant differences between soil and tuff were observed. On the other hand, flower diameter was affected by growing media. Thicker flower diameter (34.5 mm) was observed in plants grown in soil as compared to plants grown in zeolitic tuff (26.4 mm). The highest flower diameters (54.2 mm and 42.0 mm) were obtained from the control treatment in both soil and zeolitic tuff respectively. Increasing salinity decreased significantly flower diameter in both growing media

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Table 3: Flower length (cm), diameter (mm), and several inflorescences for Chrysanthemum morifolium plants grown at different salinity levels in soil and zeolitic tuff growing media.

EC	**Flower length**		**Flower diameter**		**Number of inflorescences**	
dS.m-1	Soil	Z. tuff	Soil	Z. tuff	Soil	Z. tuff
0	19.2a	20.4a	54.2a	42.0a	6.3a	7.3a
2	16.8b	17.2b	41.1b	34.0b	6.3a	6.5ab
4	15.1c	15.6bc	32.7c	23.5c	5.0ab	6.0ab
6	14.3c	14.5cd	24.4d	17.6d	5.5ab	6.5ab
8	12.8d	13.0d	19.9e	14.7d	3.8b	4.5b

Values in the same factors and column with different letters are statistically different ($p<0.05$)

The vase life of C. morifolium cut flowers was measured through the determination of relative fresh weight (RFW) for flowering shoots (Table 4). The RFW of shoots harvested from soil was significantly different at different salinity levels. Shoot RFW harvested from the soil after one day was not affected by increasing salinity levels. After 4 days, plant RFW increased significantly. The highest RFW was recorded for the control treatment while the lowest RFW was reported at 8 dS.m-1 (Table 3). Differences were not high at the different salinity levels in the soil as the loss did not exceed 17% after 10 days. RFW losses recorded after 10 and 7 days were significant for the shoots harvested from soil and zeolitic tuff.

Table 4: Relative fresh weight (g/plant) for Chrysanthemum morifolium plants grown at different salinity levels in soil and zeolitic tuff growing media.

EC	**Relative fresh weight (Vase life)**							
dS.m-1	**Soil**				**Z. tuff**			
	RFW1	**RFW4**	**RFW7**	**RFW10**	**RFW1**	**RFW4**	**RFW7**	**RFW10**
0	100a	117a	107a	93a	100a	115a	107a	91a
2	100a	110b	100b	90abc	100a	110ab	103a	88a
4	100a	107ab	100b	89ab	100a	110ab	101a	88a
6	100a	106ab	97b	85bc	100a	109ab	97a	83a
8	100a	104c	97b	82c	100a	103b	96a	83a

Values in the same factors and column with different letters are statistically different ($p<0.05$)

Effect of salinity on plants physiological responses

Leaf greenness (SPAD), stomata resistance, chlorophyll fluorescence, and RWC for C. morifolium plants grown at different salinity levels in soil and zeolitic tuff growing media are demonstrated in Table 5. Stomata resistance, SPAD, chlorophyll fluorescence, and leaf RWC were found to be significantly affected by salinity. Results showed that the highest chlorophyll content was obtained from control plants grown in soil (68.6) and in zeolitic tuff (75.1). Increasing salinity level in the growing medium caused a significant reduction in chlorophyll content for C. morifolium. Significant reductions in chlorophyll content at 8 dS.m-1 reached 50% of that in the control treatment in both soil and zeolitic tuff. C. morifolium plants grown in zeolitic tuff showed a higher chlorophyll content than those growing in soil. Stomata resistance was significantly increased by increasing salinity. Plants grown in soil under EC of 8 dS.m-1 had the highest stomata resistance (5.62 s.cm-1), this result was significant compared with all the lower salinity levels (1.97 Scm-1). In zeolitic tuff, the effect of salinity was the same as plants grown in soil. However, plants grown in soil presented more stomata resistance than zeolitic tuff. The results showed that plants are grown in soil and zeolitic tuff have the highest fluorescence yield (0.76) under control treatment. Increasing salinity level from 2 up to 8 dS.m-1 caused a significant reduction in fluorescence yield for chrysanthemum plants grown in both media. However, at the highest salinity level (8 dS.m-1), plants grown in the soil had the highest fluorescence yield. As compared to the control treatment, the reduction reached about 30% and 26% in plants grown in soil and zeolitic tuff, respectively. Increasing salinity levels in irrigation water resulted in a significant reduction in RWC for plants grown under 8 dS.m-1. Plants grown in the soil had the lowest RWC when irrigated with a salinity level of 8 dS·m-1. However, subjecting plants growing in soil and zeolitic tuff to high salinity levels caused a 46% reduction in RWC when compared to the control treatment.

Table 5: Leaf greenness (SPAD), stomata resistance (s.cm-1), chlorophyll fluorescence and relative water content (RWC) for Chrysanthemum morifolium plants grown at different salinity levels in soil and zeolitic tuff growing media.

EC	SPAD		Stomata resistance		Chlorophyll inflorescence		RWC	
dS.m-1	Soil	Z. tuff	Soil	Z. tuff	Soil	Z. tuff	Soil	Z. tuff
0	68.6a	75.1a	1.97d	1.90d	0.76a	0.76a	88.1a	87.6a
2	60.9b	63.0b	3.30c	3.00c	0.67b	0.68b	76.5b	74.6b
4	52.2c	54.3c	3.87bc	3.66bc	0.63bc	0.63b	66.8c	62.9c
6	42.3d	47.4d	4.51b	4.10b	0.61cd	0.62b	56.8d	58.1c
8	36.9e	39.3e	5.62a	5.16a	0.56d	0.53c	46.9e	47.7d

Values in the same factors and column with different letters are statistically different ($p<0.05$)

DISCUSSION

Impact of salinity on Chrysanthemum morifolium growth

The current study was performed to determine the influence of salinity on C. morifolium performance, flower yield and quality. However, salt stress has a major effect on plant growth and productivity. Salinity affects almost all aspects of plant growth and development. Irrigation with saline water causes physiological changes in stomatal resistance, transpiration, photosynthesis, chlorophyll content, and root and leaf activity (Kucukahmetler, 2000). Consequently, a reduction of flower quality (color, size, stem thickness, and length) and yield might be observed. Thus, these changes permit their use as parameters in salt tolerance screening. Furthermore, analysis of specific yield parameters may give vastly different salt tolerance rankings. For example, Devitt and Morris (1987) reported that marigold, Tagetes patula was very tolerant to salinity based on relative plant height, DW, and flower diameter, but very sensitive based on the relative number of flowers. Nevertheless, the results of the present study indicated that C. morifolium growth decreased by increasing salinity, probably in response to limited cell expansion resulting from osmotic stress (Munns and Tester, 2008). Our results showed a significant reduction in plant height as salinity level in irrigation water increased, which is go along with the findings of Kotuby-Amacher *et al.* (2000), who considered C. morifolium as a moderately tolerant plant that can tolerate salinity up to 3 dS.m-1 in irrigation water. Zapryanova and Atanassova (2009) found that C. morifolium can cope with salt concentrations up to 6 dS.m-1. Reductions in plant height were attributed to reductions in the percentage of dividing cells with increasing salt concentration in chrysanthemum (Hossain *et al.,* 2004). According to Ashraf *et al.* (2008), the reduction in plant growth may reflect the increase of metabolic energy needed to manage salts stress and reduce carbon gain due to the reduction in the rate of photosynthesis. Ghoulam *et al.* (2002) reported that salt stress may inhibit the growth of plants by causing water deficiency, reduction in metabolic activities, and nutrient deficiency due to salt ion toxicity. Our results indicated that salt treatment significantly affected C. morifolium growth in terms of shoot FW and DW. Increasing salinity levels from control up to 8 dS.m−1 caused a significant reduction in FW in the two different growing media tested. Reductions in shoot DW of C. morifolium exceeded 62% as compared to the control treatment. According to Sharma and Hall (1992), the retardation of plant growth is related to the impact of physiological activities and metabolism that result from water and nutrients stress occurring during salinity stress. In Petunia plants, shoot FW was reduced 26% by using a saline treatment of 8 dS.m-1 and there was a reduction in both the number of leaves/plant and the root size as compared to the control plants (Safi *et al*., 2005). Additionally, root growth may also be inhibited due to higher external salt concentrations by osmotic effects (Wild, 1988). Roots that absorb water and nutrient are always in direct contact with soil, therefore, it is highly important to consider total root and shoot dry weights to evaluate the salt tolerance of plants (Rani *et al*., 2012). Kafi *et al*. (2013) reported a significant reduction in plant growth due to salinity stress, and this agreed with the findings of Pessarakli and Huber (1991) who concluded that salinity stress significantly reduced the total plant DW. Shoot DW of Calceolaria was 55% lower in the saline treatment, and a reduction in the number of leaves/plant and the root size was observed as compared to the control (Safi *et al*., 2005).

Impact of salinity on Chrysanthemum morifolium flowers

Proper management of water and nutrients is necessary for ornamental plants production as their excessive application may lead to reduced growth, less yield and poor quality (Oki and Lieth, 2004). Stem length, FW and DW of a flower decreased with further increasing salinity (Ahmad *et al*., 2013). Negatively, flower FW and DW were significantly reduced by increasing salts in the growing media. Garcia-Gomez *et al*. (2002) reported a reduction in Calendula fresh weight after irrigating the plant with saline water. Plants grown under saline conditions have retarded growth and less FW caused by disturbance to water and ion balance, membrane permeability, stomatal conductivity, and photosynthesis (Navarro *et al.,* 2003; Cabanero *et al.,* 2004). Flower stem length is a vital quality attribute of ornamental plants since it influences the economic value of the cut flowers. Shoot elongation is the most sensitive growth process to water and salt stress (Wahome *et al.,* 2000). Ahmad *et al.* (2013) explained the reasons for stem length and diameter reduction. According to their point of view, the presence of high concentrations of soluble salts in irrigation water blocks the vascular system and ultimately restricts water uptake. This results in water stress which causes loss of cell turgidity and reduction in leaf expansion rates. This, in return, leads to a reduction in leaf area available for photosynthesis causing loss of stem length, stem diameter, and many losses in yield and quality. Our data showed a significant reduction in the average number of flowers produced by C. morifolium by increasing salinity level in the growing media compared to the control plants. White (2007) pointed out that for certain varieties of carnation, high salt level up to 8 dS.m-1 reduced the number of blooms, but more frequently reduced the flower size and stem length. Plants are grown with 2.5 dS.m-1 substrates EC produced taller plants with higher flower yield (Ahmad *et al*., 2013). Safi *et al*. (2007) found the highest flower yield in Lilium cultivars irrigated with pure water with no salts. They explained the high flower yield due to longer and thicker stalks and due to more buds per stalk produced by the Lilium. The present results strongly indicate that the lower the percentage of buds per stalk the higher the number of flower buds remained on the stalk concerning water type used for irrigation. Not only flower production was affected by salinity, delay in flowering as a result of irrigation with highly saline water was also observed. This delay reached about 26 days in C. morifolium plants. These findings are in agreement with those of Fornes *et al*. (2007) as they noticed a strong reduction in growth and a delay in flowering in Calceolaria plants, and Shillo *et al*. (2002) on *Trachelium* plants. Our data indicated that flower length and diameter were significantly reduced by increasing salinity level used up to 8 dS.m-1 compared to the control. Our results agreed with Kucukahmetler (2000) who reported reductions in flower quality (color, size, stem thickness, and length) and yield. Keeping quality and length of vase life are important factors for the evaluation of cut flowers quality, for both domestic and export markets. The effect of salinity on the vase life of flowering shoots was measured in terms of relative loss of relative fresh weight (RFW). Salinity decreased vase life of cut flowers of C. morifolium used in this study.

Effects of salinity on Chrysanthemum morifolium physiological response

Besides visible changes reflected on plant growth, plants also respond to salinity internally, expressed in changes in physiological and metabolic processes. To quantify the physiological responses to salinity, stomata resistance, chlorophyll fluorescence, chlorophyll content, and leaf relative water content were measured. Stomata resistance is used as a good non-destructive, rapid and easy physiological parameter to determine salt tolerance on plants subjected to different salinity levels. The impact of salinity stress on photosynthesis rate usually occurred through its effects on stomata function that depend on the type of salinity, duration of exposures, plant species, and stage of the plant growth (Flowers and Yeo, 1986). The present results indicated that stomata resistance was significantly increased with increasing salinity levels. At a high salinity level, C. morifolium plants have higher stomata resistance value as compared to the control plants. These results are in agreement with Eisa *et al*. (2012) who indicated that stomata resistance was dramatically increased with increasing salinity in irrigation water. It is considered as a physiological reaction that assists the plant to deal with salinity stress by closing its stomata to prevent the plant from facing instance physiological dehydration (Shahmersi *et al*., 2012). The chlorophyll content of C. morifolium plants was significantly decreased with increasing salinity levels. In this regard, many previous studies indicated a reduction in chlorophyll content under salt stress using different plants (Lohaus *et al*., 2000; Fornes *et al*., 2007; Turan *et al.,* 2009; Nawaz *et al*., 2010). Salinity stress reduces chlorophyll content through the inhibition of chlorophyll synthesis and acceleration of chlorophyll degradation by chlorophyllase enzyme (Qasim *et al.,* 2003). In general, a plant that possesses the highest RWC at salinity conditions can tolerate the toxic effect of salt during growth and development stages (Lee and Senadhira, 1998). Our results demonstrated a significant reduction in RWC of C. morifolium plants in response to the increased salinity level. Cicek and Cakirlar (2002) studied the physiological response of some maize cultivars to salinity level, and they found that RWC decreased after salt stress. Increased salinity decreased photosynthesis rate and reduced photosynthetic transport to the inflorescences which consequently reduces the formation and production of the flowers and results in a significant decrease in reproductive variables. Chlorophyll content of leaves of carnation and gerbera decreased with increasing the salinity stress level compared with the control (Baas et al., 1995). Salt stress causes a reduction in the growth and photosynthesis of plants, so using photosynthetic parameters such as chlorophyll fluorescence yield play an important role to determine the salt tolerance of plants. The current results indicated that the chlorophyll fluorescence yield of C. morifolium plants decreased with increasing salinity levels. Chlorophyll fluorescence and chlorophyll degradation under salt-stressed conditions are important parameters to determine the pigment stability and photosynthesis activity in the leaf tissues (Chaum and Kirdmanee, 2009). The reduction in chlorophyll fluorescence with increasing salt concentration may be attributed to the effect of the salt on the reaction center of photosystem II or acceleration in leaf senescence (Lazar, 2006). Moreover, Redondo-Gomez et al. (2007) reported that a decrease in chlorophyll fluorescence is due to impaired photosystem II and photochemical activity, which leads to damage in the functionality of the photosynthetic apparatus.

Effect of growing media on Chrysanthemum morifolium

In our findings, plants grown in zeolitic tuff were performed better than those grown in soil in some parameters. In this regard, Safi *et al.* (2005) indicated that a higher carnation yield was obtained when the plants were grown in zeolitic tuff. Ramesh *et al*. (2011) found that using zeolites is better due to their unique physical and chemical properties including ion exchange, dehydration-rehydration, and adsorption properties made them useful in agricultural applications and environmental engineering as they were found to increase crop yield and to promote nutrient use efficiency. Abdi *et al.* (2006) reported that zeolite increased the rate of photosynthesis due to the availability of different elements and water for the plants. Applying zeolite to the potting medium of C. morifolium behaved like a slow-release K-fertilizer that enhanced growth (Mumpton, 1999).

In conclusion, two findings are worth noting. The first one is that most of C. morifolium tested parameters are affected by salinity level and growing media. The second one is that a salinity level of 2 dS.m-1 using soil as a growing media gave the best results from the standpoint of production and can be successfully produced economically feasible ornamental crops. However, more research regarding how salinity can be used to restrict retardation in growth without damaging the plant's developmental rate has to be conducted

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أداء نبات أقحوان زهرة الغريب أو أقحوان توتي الأوراق (بلدي .Chrysanthemum morifolium (CV Ramat (CV. Balady) تحت تأثير ملوحة مياه الرّي و أوساط زراعية المتنوعة

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الملخص

نتيجة لتناقص توافر مياه الري عالية الجودة، تزداد اهمية تحمل ازهار القطف للملوحة. تم تقييم تاثير الملوحة على نمو وجودة نمو نبات اقحوان زهرة الغريب او اقحوان توتي الاوراق في وسطين مختلفين تحت اربعة مستويات ملوحة. تمت زراعة اشتال نبات اقحوان زهرة الغريب في اوعية بلاستيكية تحتوي على التوف الصخري او التربة كوسائط للزراعة. تعرضت شتلات نبات اقحوان زهرة الغريب لأربعة مستويات ملوحة بالإضافة الى الشاهد (dS/m−1 0,2,4,6,8) من محلول مكون من 85% كلوريد الصوديوم و15% كلوريد الكالسيوم حسب الوزن, وتم دراسة تأثير زيادة مستويات الملوحة المتنوعة على النمو وخصائص الإزهار ووقت الإزهار وطول وقطر النورات الزهرية وقطر الزهرة الطرفية على كل ساق، وفي نهاية التجربة، أخذت قياسات طول النبات، الغطاء النباتي، الوزن الجاف والرطب لبراعم النبات، أشارت النتائج إلى أن معظم قياسات الصفات المدروسة انخفضت معنويا بارتفاع نسب الملوحة، إذْ أدت زيادة الملوحة إلى انخفاض في طول النبات والوزن الرطب والجاف للمحصول ونسبة المحتوى المائي، علاوة على ذلك أدت الملوحة إلى انخفاض جودة الأزهار (اللون والحجم وسمك الساق وطوله) والإنتاجية، وحدثت بعض التغيرات الفسيولوجية في مقاومة الثغور ونسبة المحتوى المائي ومحتوى الكلوروفيل في الأوراق، وأظهر نبات الغريب مقاومة جيدة للملوحة عند رّي النباتات بمياه مالحة حتى مستوى 4 dS.m−1. وجد اختلافات في استجابات نبات التجربة بين الأوساط الزراعية المتنوعة المستخدمة في الزراعة سواء في التربة أو التوف الصخري للصفات المختبرة، إذْ إن استخدام التوف الصخري كان أفضل في تحمل مستويات الملوحة العالية مقارنة مع الأشتال المزروعة في التربة كوسط زراعي. وبناءً على نتائج هذه الدراسة فانه يوصى باستخدام التوف الصخري بدلاً من التربة عند الري بمياه مالحة للحد من مشكلة ملوحة المياه المستخدمة في الرّي

الكلمات الدالة: أقحوان زهرة الغريب أو أقحوان توتي الأوراق، الملوحة، وسط الزراعة، التوف الصخري، نباتات الزينة، الأردن.