Alireza Dadkhah and Gh.Rassam

Effect of Salt Stress on Growth and Essential oil of *Matricaria chamomilla*

Introduction

Salinity is a major environmental stress affecting plant growth and productivity. Salinity effects are more conspicuous in arid and semi-arid areas where 25 % of the irrigated lands are affected by salts. The ability of plants to cope with salt stress is an important determinant of crop distribution and productivity. An excess of soluble salts in the soil leads to osmotic stress, specific ion toxicity and ionic imbalances (Munns 2003) and the consequences of these can be plant death or yield losses in both crop species and medicinal plants (Rout and Shaw, 2001). Ashraf *et al.* (2004) found that increasing salt concentrations caused a significant reduction in the fresh and dry masses of both shoots and roots as well as seed yield of *Ammolei majus*, while reduced plant fresh and dry weight in *Hyoscyamus niger*. It was reported that salinity increased phenolic acids in *Matricaria chamomilla* plants (Kovacik *et al.*, 2009). Belaqziz *et al.* (2009) showed that the aerial part oil content of Thyme species did not change with increase in external salt level.

In Iran (mostly arid and semi-arid with saline-alkaline soil), there are more than 7500 plant species which most of them have valuable active substances. One of the most important species of them is Chamomile, an annual plant belongs to Asteraceae family, grows widely in various ecological zones of Iran (Afzali *et al.*, 2006). Chamomile flowers have active substance that is called essential oil in which the most important constituent is chamazulene that is used widely in pharmaceutical, food, perfumery and flavouring industry (Galambosi and Holm, 1991). The annual world consumption of chamomile flowers is more than 4 000 ton (Franz *et al.*, 1986). Recently its cultivation in some part of Iran such as Tehran, Lorestan, Khozestan, Fars and Isfehan provinces has started and several drugs have produced from its essential oil. This is very important to reduce chemical drugs and increase individual health.

In view of importance of Chamomile as potential medicinal herb, which is being used for treatment a number of diseases (Simpson 2001), an experiment was conducted to assess the effect of salt stress on growth and essential oil of chamomile plants.

Materials and Methods

This study was carried out at the Department of Medicinal Plants, Shirvan College of Agriculture, Ferdowsi University of Mashhad, Iran. Pot experiment based on randomized complete block design was carried out in green house conditions with six replications.

Seed of chamomile (*Matricaria chamomilla*) were kindly provided by the Agricultural Research Center of Isfehan and were sown 1 mm deep in plastic containers filled with sand. After emergence, seedlings were transplanted to 15 cm diameter plastic pots containing one part loamy soil and two parts sand. Four levels of salinity including control (0 mM), 50, 150 and 250 mM NaCl and $CaCl_2$ in a 5 : 1 molar ratio were added to the modified Hogland nutrient solution (Mass and Poss 1989). Two week after transplanting, seedlings were irrigated with saline water. To prevent shock to plants, irrigation started with 50 mM saline water and was increased by 50 mM every other day until reaching each salinity level. In addition the pots were flushed out with saline water every week to ensure homogeneity of salinity and nutrient supply in growth medium. This was checked by measuring the electrical conductivity (EC) of the drainage water. Water lost by evapo-transpiration of plants and pots was replaced by tap water. Plant height, plant dry weight, the number of branches per plant, the number of flower per plant and dry weight of flowers per plant were measured. Flowers dried at room temperature. A 10 g sample of dried and threshed flowers was mixed with 500 ml of distilled water in flask and mixture was distilled for 8 h using a Clevenger type apparatus.

Abstract

A pot experiment based on complete blocks design was carried out to investigate the effect of salinity on growth traits and essential oil content of chamomile (*Matricaria chamomilla* L.). Four levels of salinity including control (0 mM), 50, 150 and 250 mM Nacl and $CaCl_2$ in 5 : 1 molar ratio were used. Result indicated that increased salinity caused reduction in plant height, number of branches per plant, number of flowers per plant. Increased salinity also significantly decreased plant dry weight, flower dry weight and essential oil content. The highest values of growth traits such as number of flower per plant, flower dry weight and essential oil content were observed under control condition (non-salinity stress). The effect of salinity on flower dry weight is greater than other traits. Flower dry weight of plants at low (50mM) level of salinity was decreased 12.2 % compared to control (non-stressed plant) while essential oil content increased 18.2 % at the same salt concentration. At the highest level of salt stress (250mM) flower dry weight and essential oil content was decreased by 79.8 and 45.5 % compared to non stressed plants, respectively. Number of flower per plant was decreased by 16.1 and 69.2 % at lowest (50 mM) and highest (250 mM) salinity concentration respectively. Salinity affects flowering time of plants. Flowering time of non-stressed plants started 50 days after plant transplanting while flowering time of plants treated by 250 mM salinity started 64 days after seedlings transplanting to pots.

Keywords

Chamomile, Plant growth, Salinity, NaCl, $CaCl_2$,

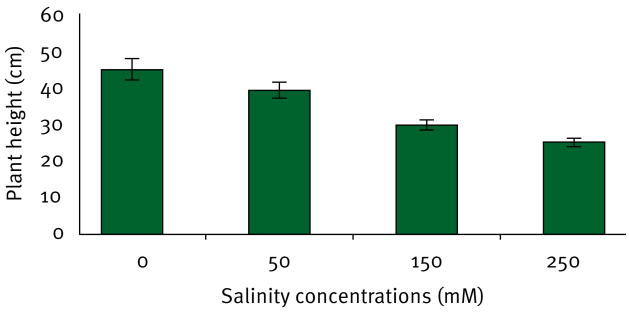

Fig. 1: Effect of different salinity concentration on plant height of chamomile plants. Each bar is the average of six replications. Vertical lines are standard error of the means.

Abb. 1: Der Effekt unterschiedlicher Salzkonzentrationen auf die Wuchshöhe. Jeder Balken repräsentiert den Mittelwert aus sechs Wiederholungen. Dargestellt ist der Standardfehler des Mittelwertes als vertikale Linien.

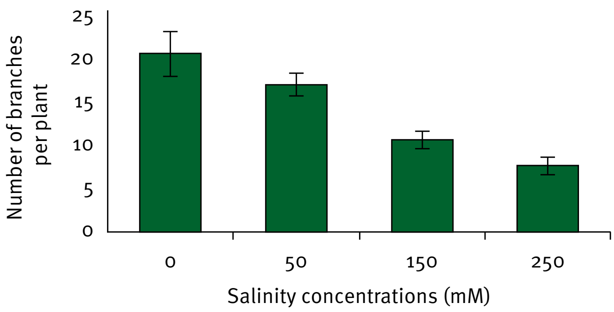

Fig. 2: Effect of different salinity concentration on number of branches per plant of chamomile plants. Each bar is the average of six replications. Vertical lines are standard error of the means.

Abb. 2: Der Effekt unterschiedlicher Salzkonzentrationen auf die Anzahl der Sproßverzweigungen. Jeder Balken repräsentiert den Mittelwert aus sechs Wiederholungen. Dargestellt ist der Standardfehler des Mittelwertes als vertikale Linien.

The essential oil content was measured. Data were analyzed using SAS statistical program. Means were compared by Duncan's multiple range tests at the 0.01 probability level for all comparisons.

Results and Discussion

Salinity affects all growth traits of chamomile plant but the response of them varied. Plant height was greatly reduced by salinity (*Fig. 1*). Plant height at low (50 mM) and high level of salinity (250 mM) was decreased 12.6 and 44 % compared to plant height of non-stressed plants at the end of season (*Fig. 1*). The number of branch per plant significantly decreased as salinity increased. The number of branch at highest salinity (250 mM) was decreased 63% compared to control plants (non-stressed plants) (*Fig. 2*). The number of flower per plant also was reduced by salinity. The number of flowers per plant at low (50 mM) and high (250 mM) levels of salinity decreased by 16 and 69.2% compared to control plants respectively (*Fig. 3*). Salinity had significant effect on flower dry weight per plant (*Fig. 4*). The effect of salinity on flower dry weight is greater than the effect of salinity on other traits, so that flower dry weight of plants treated with 250 mM salinity decreased by 79.8 % compared to non-stressed plants. Reduction in flower dry weight due to salinity may be a cumulative effect of decline in the number of flowers per plant. Salinity affects flowering time of plants. Flowering time of non-stressed plants started 50 days after plant transplanting while flowering time of plants treated by 250 mM salinity started 64 days after seedlings transplanting to pots (data not shown). Although low level of salinity appeared to stimulate essential oil content, higher salt concentrations significantly decreased essential oil content (*Fig. 5*). Low level of salinity stimulates essential oil content. However, higher salt concentrations significantly decreased essential oil content from 1.1% in control treatment to 0.6 % at 250 mM salinity level.

The results showed that plant height, number of branches per plant and flowers dry weight per plant was adversely affected with increasing salinity. Such an adverse effect of salt stress on growth traits has been observed in many plants. This reduction was closely linked to slower cell production and development of smaller stems. This is consist with the result of previous research which showed that high levels of salinity decreased plant growth due to a combination of a decrease in cell number and in cell size (De Herralde *et al.*, 1998). Munns (2003) reported that suppression of plant growth under saline conditions may either be due to decreased availability of water or to the toxicity of sodium chloride. It was hypothesized that growth reduction in response to salt stress was related to the restriction of the synthesis of plants growth promoters such as cytokinine and the increase in the production of the inhibitors such as abscisic acid

Effekte unterschiedlicher Salzkonzentrationen auf das Wachstum und den Gehalt an ätherischem Öl von *Matricaria chamomilla*

Zusammenfassung

Vier Versuchsvarianten, die mit 0 mM, 50 mM, 150 mM und 250 mM NaCl, so wie mit CaCl2 behandelt wurden, zeigten eine reziproke Korrelation zwischen Salzkonzentrationen und Wuchshöhe, Anzahl der Sproßverzweigungen und der Anzahl der Blüten. Steigende Salzkonzentrationen führten weiterhin zu geringerer Pflanzen- und Blütentrockenmasse, so wie zu geringeren Gehalten an ätherischem Öl. Die höchsten Werte bezüglich Anzahl der Blüten, Blütentrockenmasse und Gehalt an ätherischem Öl wurden unter Versuchsbedingungen der negativen Kontrolle (NK), ohne zusätzliche Gabe von Salz gefunden. Die größten Unterschiede zwischen behandelten Varianten und der negativen Kontrolle wurden bei der Blütentrockenmasse und dem Gehalt an ätherischem Öl festgestellt. In der Variante 50 mM NaCl lag die Blütentrockenmasse 12,2 %, der Gehalt an ätherischem Öl 18,2 % unter dem Wert der NK. In der Variante mit der höchsten Salzkonzentration lagen diese Werte 79.8 % (Blütentrockenmasse) und 45.5 % (Gehalt an ätherischem Öl) unter den Werten der NK.

Die Anzahl der Blüten pro Pflanze lag bei der Variante mit geringster zusätzlicher Salzgabe (50mM) 16,1 % , bei höchster Salzkonzentration (250 mM) 69,2 % unter den Werten der Kontrolle. Der Beginn der Blüte verzögerte sich bei der Variante mit 250 mM NaCl um 14 Tage nach Pikieren verglichen mit Pflanzen ohne Salzstress.

Schlagwörter

$CaCl_2$, Kamille, NaCl, Pflanzenwachstum, Salzgehalt

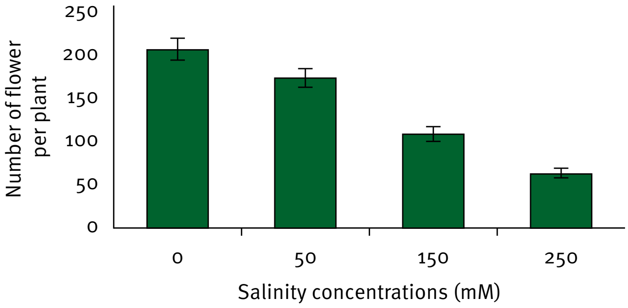

Fig. 3: Effect of different salinity concentration on number of flower per plant of chamomile plants. Each bar is the average of six replications. Vertical lines are standard error of the means.

Abb. 3: Der Effekt unterschiedlicher Salzkonzentrationen auf die Anzahl der Blüten. Jeder Balken repräsentiert den Mittelwert aus sechs Wiederholungen. Dargestellt ist der Standardfehler des Mittelwertes als vertikale Linien.

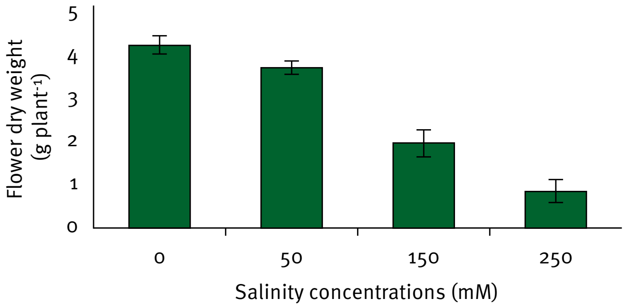

Fig. 4: Effect of different salinity concentration on flower dry weight of chamomile plants. Each bar is the average of six replications. Vertical lines are standard error of the means.

Abb. 4: Der Effekt unterschiedlicher Salzkonzentrationen auf die Blütentrockenmasse. Jeder Balken repräsentiert den Mittelwert aus sechs Wiederholungen. Dargestellt ist der Standardfehler des Mittelwertes als vertikale Linien.

(Ungar, 1991). Razmjoo *et al.* (2008) reported that the reduction in dry weight under saline condition may be attributed to inhibition of hydrolysis of reserved foods and their translocation to the growing shoots. Other authors have suggested that the reduction in growth parameters would be due primarily to the reduction of the water absorption and nutrient deficiencies (Bajji *et al.*, 2002). Pessarakli and Tucker (1988) reported that a possible reason for growth reduction could be the grater reduction in uptake and utilization of mineral nutrients by plants under salt stress. They found that total nitrogen uptake of cotton plants decreased with increasing salinity reflecting primarily a dry matter reduction. The uptake of N in salt stressed plant might be competitively limited by Cl^- (Ward *et al.*, 1986).

The essential oil content increased from 1.1 % in control treatment to 1.3 % (18 % increasing) at low level (50 mM) of salinity (*Fig. 5*). Holtzer *et al.* (1988) believed that depending upon the plant species and plant genotype, stress can increase, decrease or have no effect on the levels of metabolites. Shabih *et al.* (1999) reported limited stressful environments may stimulate the production of secondary metabolites such as essential oil. However higher salt concentration significantly decreased essential oil content. Ashraf *et al.* (2004) showed that oil content in seed of medicinal plant *Ammolei majus* was decreased consistently with increasing salinity. The reduction in essential oil content may be due to disturbance in photosynthesis and carbohydrate production under stress condition and suppression of the plant growth (Flexas and Medrano, 2002). Dadkhah (2011) reported that salinity caused a significant reduction in leaf net photosynthesis consequently total carbon fixed in leaves of plant. Salinity stress imposes additional energy requirements on plant cells and less carbon is available for growth and flower primordial initiation and then less essential oil may be synthesized (Cheesman, 1988).

Conclusion

Chamomile was moderately tolerant to salinity because salinity inhibited various growth parameters of this plant to various degrees. The flower dry weight per plant indicates a greater reduction due to increased salinity than other traits. Salinity higher than 50 mM may reduce plant growth. Even, if the production of the essential oil was not affected by salinity, it was not recommended to cultivated chamomile exceed the critical values (50 mM in this study).

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References

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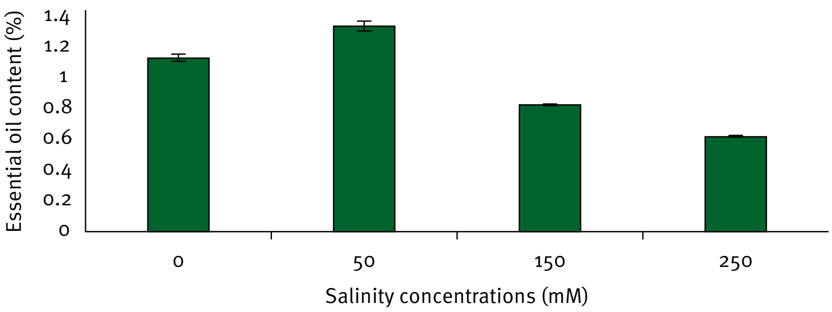

Fig. 5: Effect of different salinity concentration on essential oil content of chamomile plants. Each bar is the average of six replications. Vertical lines are standard error of the means.

Abb. 5: Der Effekt unterschiedlicher Salzkonzentrationen auf den Gehalt an ätherischem Öl. Jeder Balken repräsentiert den Mittelwert aus sechs Wiederholungen. Dargestellt ist der Standardfehler des Mittelwertes als vertikale Linien.