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The Effects of Ca Application on Some Stress Parameters Under Salinity Conditions in the Open Field Growıng of *Limonium sinuatum*

Açık Alanda Tuzlu Koşullarda Yetiştirilen *Limonium sinuatum* Bitkisinde Kalsiyum Uygulamalarının Stres Parametreleri Üzerine Etkileri

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Key Words:

Limonium sinuatum (Statice), salt stress, calcium.

ABSTRACT

A study was conducted to determine the effects of calcium on particular stress parameters (leaf relative water content, chlorophyll, carotenoid, proline and lipid peroxidase) of *Limonium sinuatum* grown in saline conditions. It was observed that the application of 30 mM calcium had positive effects on the salt stress responses of *Limonium sinuatum* when cultivated in saline soils. Calcium applications, under saline conditions, caused a slight increase in leaf relative water content or chlorophyll a, chlorophyll b and total chlorophyll values. While carotenoids and proline contents demonstrated a slight decrease in calcium applications under saline conditions, it is observed that MDA levels have shown mildly decreases. With respect to yield also the number of flowers, the length of flower stem and the thickness of flower stem were measured per harvested plant, where Ca applications under salt conditions increased flower stem length and thickness. The research improved that calcium apllication reduced the negative effects of saline conditions.

Anahtar Sözcükler:

Limonium sinuatum, tuz stresi, kalsiyum.

ÖZET

Araştırma tuzlu koşullarda yetiştirilen *Limonium sinuatum* bitkisinde bazı stres parametreleri (yaprak oransal nem içeriği, klorofil, karotenoid, prolin ve lipid peroksidaz) üzerine kalsiyumun etkilerini belirlemek amacıyla yürütülmüştür. Tuzlu toprak koşullarında *Limonium sinuatum* yetiştiriciliğinde 30 mM kalsiyum uygulamasının tuz stresi koşullarını iyileştirici yönde olumlu etkileri olduğu belirlenmiştir. Tuzlu ortamda kalsiyum uygulamaları yaprak oransal nem içeriklerinde hafif bir artışa neden olurken, klorofil a, klorofil b ve toplam klorofil değerlerinde de artışlar ortaya koymuştur. Karotenoid ve prolin içeriklerinde tuzlu ortamdaki kalsiyum uygulamaları ile azalma görülürken, MDA seviyelerinde ise çok hafif düzeyde azalışlar göstermiştir. Ayrıca verim ile ilgili olarak bitki başına hasat edilen çiçek sayısı, çiçek sapı uzunluğu ve çiçek sapı kalınlığı ölçümleri de gerçekleştirilmiştir. Tuzlu ortamdaki kalsiyum uygulamaları çiçek sapı uzunluğu ve kalınlığında her iki çeşit içinde artışlara sebep olmuştur. Bu çalışmada kalsiyum uygulamasının tuzlu koşulların olumsuz etkisini azalttığı görülmüştür.

INTRODUCTION

Limonium sinuatum, of the Plumbaginaceae family, is rapidly becoming a commercially important species in the world (Anonymous, 2002). Even though commercial production is relatively new in Turkey, there are important endemic species belonging to *Limonium* genus in Turkey.

Limonium sinuatum, which is identified as a Halophytic plant group, is an ornamental plant that is suitable for many different uses. It is commonly utilized as fresh-cut or dried flowers, it also is used outdoor as a seasonal ornamental plant in rock gardens and border areas of landscape (Hatipoğlu and Gülgün, 1999).

Since *L. sinuatum* is not selective about the soil type on which it is grown, it can be grown on every type of soil except predominantly clay soil (Anonymous, 2008). Currently, *L. sinuatum* is grown on drought-prone and saline soils, and may become increasingly valuable as halophytic plant due to global warming. Even if it is irrigated with water possessing 30 dS/m electrical conductivity, it still has the ability to grow through its life cycle (Carter et al., 2005). With these characteristics, as well as its typical usage as a seasonal ornamental plant in landscaping of the hotels on the seaside/coasts with high salt ratio it has increased coastal diversity. It is a seasonal ornamental plant, which can be used especially in creating rock gardens and borders. Natural species can grow on land containing saline soils, and it is also possible to potentially increase usage of these soils by these plants in the areas requiring landscaping.

Arable land is limited on earth and there is a rapidly increasing need for food due to population growth, hence it is necessary to evaluate more efficient ways to use land. Reclamation and economic utilization of existing saline lands is extremely important (Woods, 1996). Halophytic and other salt-resistant plants are good alternatives for developing countries with saline soils (Aranson, 1989). These plants have ability to tolerate higher salt ratios by using their eco-physiological structures, thus they can be grown in extremely saline habitats. Halophytic plants can grow naturally on saline semi-deserts, mangrove swamps, marshes, degraded soil types and on coastal lands. They can be also grown on salt affected soils (El Shaer, 2010). Despite the low economic values of halophytic and salt-resistant plants, they are very important due to the fact they can grow on saline lands (Dinga et al., 2010).

To ensure the continuity of agricultural production, the salinity level limiting the cultivation ratio must be within a range where a plant could continue its life cycle. Many studies have been conducted on this topic, and it has been observed that calcium has a very important role in increasing the salt-resistant ratio of plants grown on saline lands (Navarro et al., 2000; Türkmen et al., 2002; Parida and Das, 2005; Tuna et al., 2007). Calcium, as an experimental parameter, acts as a key regulator of plant growth and development (Hepler, 2005). Plants gain calcium as divalent cations, Ca^{+2}, where typically there is an exchange between calcium and potassium in cell membranes. The calcium quantity taken up by the plant is partly related to the genetic background of the plant. In the cell tissues, a large amount of the calcium is incorporated into the cell walls. Calcium stays in the cell walls as pectates, and has the basic role of strengthening of the cell walls and cell tissues. Another important role of calcium in plants is in root elongation and cell division (Kacar and Katkat, 2006).

When cultivation is made in saline soils, as the osmotic potential increases, the plant may not be able to take up more water efficiently, and toxic effects can occur, with deterioration of the ion balance caused by the high values of Na and Cl ions in saline soils (Taban et al., 1999; Essa, 2002).

Some researchers have reported that plants can has increase the salt-resistance ratio by reducing uptake of salt by means of competition with Na in the zones of leaf and root, when the compounds of either Ca, K or P, are applied externally under salt stress (Kaya and Higgs, 2002; Yakıt and Tuna, 2006).

In this study herein, we aim to determine the stress parameters and the effects on efficiency when there are applications of calcium to *L. sinuatum* grown in saline conditions.

MATERIALS AND METHODS

Research was conducted by using a randomized complete block design with 3 replicates, six plants of each repetition. 'Compindi White' and 'Compindi Deep Blue' of *L. sinuatum* were used as the plant material. Two calcium dosages were tested: 0 and 30 mM.

Seedlings were germinated and grown in a synchronized manner by a private firm, then placed into 0.5 liter black PE pots. The planting mix peat:perlite (1:1) was used and then the seedlings were re-planted in their original saline soil outside. The pH was 6.44, total salt 0.061 %, organic material content 20.10 %, and the total nitrogen amount 2.23 % were obtained after the analyzing of the procedure performed mentioned above (These values are approximate ones).

Saline soil material was taken from the coastal area and this areas can not be use in agriculture. Physical and chemical properties of soil materials are given on Table 1.

Table 1. Physical and chemical properties of soil material used in the experiment

Analysis	Control soil	Saline soil
pH	7.56	8.13
Total Salt (%)	0.085	0.674
Lime (%)	14.41	20.70
Sand (%)	65.28	25.28
Shaft (%)	24.00	48.00
Clay (%)	10.72	26.72
Structure	Sandy loam	Loam
Organic matter (%)	4.80	2.06
Total N (%)	0.30	0.090
Available P (ppm)	89.54	19.22
Available K (ppm)	2619	272
Available Ca (ppm)	4606	5586
Available Mg (ppm)	275	503
Available Na (ppm)	329	5640
Available Fe (ppm)	9.79	8.88
Available Zn (ppm)	4.99	1.34
Available Cu (ppm)	3.01	1.42
Available Mn (ppm)	15.13	10.12

The plots are 1.20 m in width, 4 m length and 0.7 m in depth. Seedlings were planted in 30x30 cm squares. modified Hoagland nutrient solution used for nutrition once in 15 days by drip irrigation.

From the application of calcium, a monthly assessment of leaf relative water content analysis (Yamasaki and Dillenburg, 1999) was made, and at the end of the 3th month, chlorophyll (Arnon,1949), carotenoid (Strain and Svec, 1966), proline content (Bates et al., 1973) and lipid peroxide analysis (Hodges et al., 1999) were done.

By means of harvesting once a week, total number of harvested flower per plant, the length of flower stem and the thickness of flower stem measurements were performed.

The Tarist program is used to evaluate obtained data statistically.

RESULTS AND DISCUSSION

In two different cultivars of *L. sinuatum*, 'Compindi White' and 'Compindi Deep Blue' the affects of calcium were assessed on leaf relative water content, chlorophyll, carotenoid, proline content, lipid peroxidation relative to total number of flowers, length of flower stem, thickness of flower stem and particular stress parameters per harvested plant.

Lengths of flower stem were analyzed, indicating a decrease of 20.98 % and 26.09 % in 'Compindi White' and 'Compindi Deep Blue' cultivars, respectively, depending on the saline conditions. It was found that decreases had influence at the level of 5 % for both cultivars (Table 2). Akat (2008) indicated that applications of salt have an important negative impact on the length of flower stems of *Gerbera jamesonii*. Considering the applications the length of flower stem under saline conditions and at control parcels showed a slight increase depending on calcium in 'Compindi White', on the other hand in 'Compindi Deep Blue' this increase is 56.91 % and it is found that these increases are significant at the level of 5 %. This is consistent with other studies (Kandeel et al., 1999; Carter et al., 2005; Carter et al., 2010; Grieve and Poss, 2010).

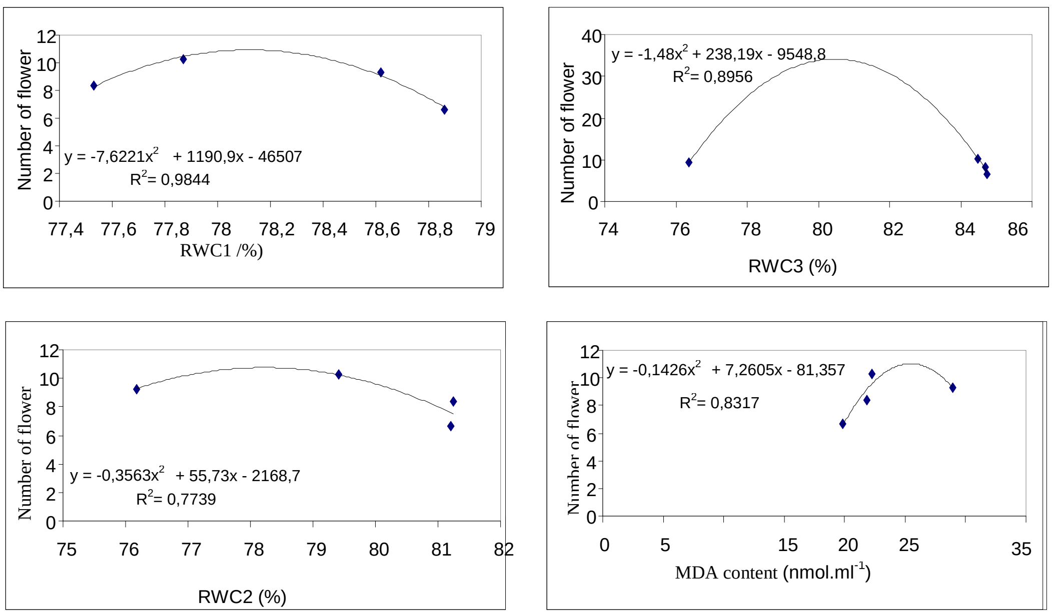
The thickness of flower stem was also dependent on salt concentration, indicating a 18.64 % decrease in 'Compindi White', and 24.92 % in 'Compindi Deep Blue' (Table 2). The effect of calcium application under saline conditions was shown by slight increases in both cultivars. These increased ratios were calculated as 3.72 % and 6.78 % in 'Compindi White' and 'Compindi Deep Blue', respectively. These results are consistent with that reported by Carter et al. (2005), Carter et al. (2010), Dinga (2010).

Table 2. The effects of calcium applications on the number of flowers, the length of flower stem and the thickness of flower stem of *L. sinuatum* plant under saline conditions

	***L. sinuatum* 'Compindi White'**			***L. sinuatum* 'Compindi Deep Blue'**		
Applications	**Flower stem length (cm)**	**Flower stem thickness (cm)**	**Number of flowers**	**Flower stem length (cm)**	**Flower stem thickness (cm)**	**Number of flowers**
Control soil	19.64 a	2.36	8.47	21.04 a	3.25	3.48
Saline soil	15.52 b	1.92	9.02	15.53 b	2.44	2.35
$LSD_{0.05}$	3.05*	n.s	n.s	4.60*	n.s	n.s
Control soil * 0 mM Ca	18.46	2.07	6.65	22.41 a	3.53	3.67
Control soil * 30 mM Ca	20.82	2.64	10.28	19.66 a	2.97	3.30
Saline soil * 0 mM Ca Saline	15.08	1.88	9.68	12.09 b	2.36	3.75
soil * 30 mM Ca	15.96	1.95	8.36	18.97 a	2.52	0.95
$LSD_{0.05}$	n.s	n.s	n.s	6.51*	n.s	n.s

There were increases and decreases that appeared not very different for either cultivar, when the number of flower per harvested plant was considered. Regression analysis provided an efficient evaluation of the number of flowers criteria. A regression analysis revealed interesting regression coefficients for 'Compindi White', where there was polynomial increase with a high regression coefficient between the number of flowers and thickness of flower stem, and the number of flowers and length of flower stem. In 'Compindi Deep Blue' there are slight increases and decreases. However, there were remarkable polynomial increases observed when examining 'Compindi White'.

By analysis, polynomial indicators were observed for comparisons of number of flowers and leaf relative water content (RWC), chlorophyll b, total amount of chlorophyll, proline, MDA contents to physiological characteristics in both cultivars (Figure 1 and 2).



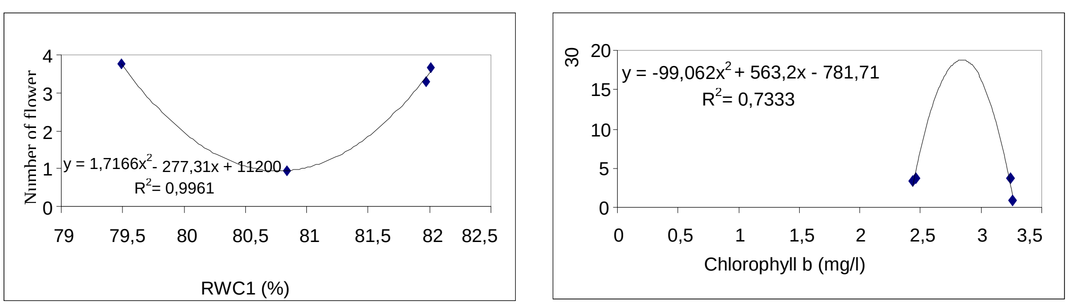
RWC1: 1. Period relative water contend

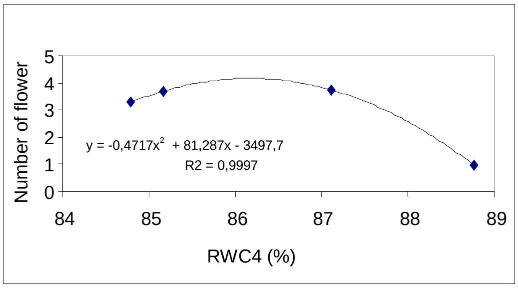
RWC2: 2. Period relative water contend

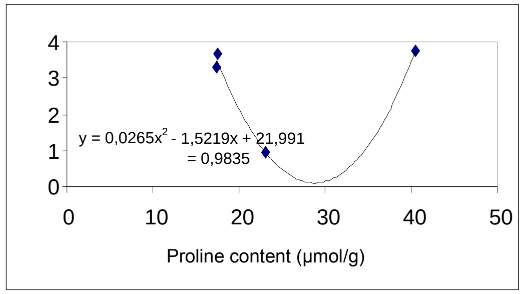
RWC3: 3. Period relative water contend

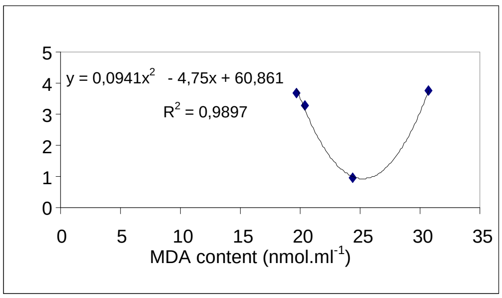
MDA: Malondialdehid

Figure 1. Regression graphs and equations comparing between 'Compindi White' number of flowers and RWC1, RWC2, RWC3 and MDA contents









RWC1: 1. Period relative water contend

RWC4: 4. Period relative water contend

MDA: Malondialdehid

Figure 2. Regression graphs and equations comparing between 'Compindi Deep Blue' number of flowers and RWC1, RWC4, chlorophyll b, proline and MDA contents

Water stress as caused by salt is very important to plant health. Typical reactions of plants under stress conditions include decreased leaf relative water content, and decreased water potential. However, the most obvious symptom of plants under stress is the loss of turgor followed by wilting, then drying of vegetative mass. Therefore, when determining the water content in plants, it is important to know the leaf relative water content value and observations of changes in the plants (Yamasaki and Dillenburg, 1999). Osmotic pressure increases when the salt concentration increases, thus it comes more difficult for the plant take water from the soil, and therefore leaf relative water content values decreases. The growth of the plant slows down, even stops over time as a result of the factors aforementioned (Kanber et al., 1992; Güngör and Erözel, 1994).

To this end, the leaf relative water content values were examined periodically in this research. Except for the 4th measurement period, there were decreases in leaf relative water content values, for both cultivars with respect to salinity levels. In studies regarding leaf relative water content, it has been observed that leaf relative water content values are decreased under salt stress conditions (Sivritepe, 2002). There were slight increases in leaf relative water content values in calcium application under saline conditions in the 2nd, 3rd, and 4th periods recorded for both cultivars except for the 1st measurement period of 'Compindi White'. Values are 5.07 %, 6.53 % and 8.32 % in 'Compindi White', respectively (Table 3). There were also increases in leaf relative water content values for 'Compindi Deep Blue'. The measured values for 'Compindi Deep Blue' are 1.35 % in the 1st measurement period, 5.29 % in the 2nd period, 7.47 % in the 3rd period, and 1.66 % in the 4th period. These results are consistent with the trend reported on the effects of Ca, Mg, and K on the stress parameters of the plant under saline conditions by Yakıt and Tuna (2006). In this research herein, it is also concluded that salt has a negative influence on the leaf relative water content, and calcium application has positive effects.

Table 3. The effects of calcium applications on leaf relative water content of *L. sinuatum* plant under saline conditions

	***L. sinuatum* 'Compindi White'** **Leaf relative water content (%)**				***L. sinuatum* 'Compindi Deep Blue'** **Leaf relative water content (%)**			
Applications	**1.Period (%)**	**2.Period (%)**	**3.Period (%)**	**4.Period (%)**	**1.Period (%)**	**2.Period (%)**	**3. Period (%)**	**4.Period (%)**
Control soil	78.37	80.31	81.75	84.60	81.99	80.36	80.12	84.98
Saline soil	78.08	78.72	81.41	80.53	80.16	74.65	78.46	87.94
$LSD_{0.05}$	n.s	n.s	n.s	n.s	n.s	5.39*	n.s	n.s
Control soil * 0 mM Ca	78.86	81.21	81.05	84.73	82.01	79.08	81.86	85.17
Control soil * 30 mM Ca	77.87	79.41	82.44	84.47	81.97	81.63	78.38	84.79
Saline soil * 0 mM Ca	78.62	76.18	77.14	76.37	79.49	72.01	74.72	87.11
Saline soil * 30 mM Ca	77.53	81.25	83.67	84.69	80.84	77.30	82.19	88.77
$LSD_{0.05}$	n.s	3.88*	n.s	n.s	n.s	n.s	n.s	n.s

It is well known that the formation of chlorophyll is the milestone of autotrophic structure in plants. Photosynthetic metabolism plays a very important role in growth and biomass in plants. Chlorophyll a, chlorophyll b, total amount of chlorophyll and the amount of carotenoids are important indicators for the effectiveness of photosynthetic metabolism. The amount of chlorophyll decreases in high salt concentrations with regard to control trials (Franco et al., 1993; Tıpırdamaz and Ellialtıoğlu, 1994; Sivritepe, 1995). Salt stress can cause death of plants. Salt also has negative effects, depending on tolerance of specific plants on the growth and development of plants. Salt can cause chlorosis and necrotic spots in plants because of the destruction of the chloroplasts (Hasegawa et al., 1986). As it is well known, there is a general decrease in the amount of chlorophyll with increase in salinity.

Under salt stress conditions, Na replaces with Mg in molecular level, thus the structure of chlorophyll is deteriorated, even disintegrated, therefore development of the plant is influenced. The plants, which has ability to prevent the replacement of Na, under stress conditions, with Mg and has ability to increase the amount of chlorophyll, are considered as salt-resistant plants (Köşkeroğlu, 2006; Durdu 2007).

Chlorophyll a, chlorophyll b, and total amount of chlorophyll increased by 1 % in both cultivars under saline conditions (Table 4). These results are in contradiction with the results of Franco et al. (1993), Hermandez et al. (1995), Sivritepe (1995) and Kuşvuran et al. (2008). Nevertheless, these results are consistent (by increasing values of chlorophyll a, chlorophyll b, and total amount of the chlorophyll) with Makela et al. (1999), Wand and Nil (2000) and Durdu (2007) when the plants are subjected to salt stress.

The calcium applications under saline conditions increased the measured values of chlorophyll a, chlorophyll b and the total amount of chlorophyll in 'Compindi White', although there was not any significant effect, and numerical increases were also observed for 'Compindi Deep Blue'.

An important relationship between photosynthesis and leaf characteristics is explained as the potential ability of the plant to carry out photosynthesis, with relation to the total leaf area of the plant, and the photosynthesis activity of each leaf correspondingly related to the amounts of chlorophyll and carotenoids (Çırak and Esendal, 2006). Carotenoid has an important role in the center of photosynthetic reaction in photosynthetic systems. carotenoids participate in energy transfers, and protect the reaction center from oto-oxidation. ß-carotene and xanthophylls have important antioxidant effects in photosynthetic systems (Kocaçalışkan, 2002).

The alteration of leaf carotenoid content of these aspects were examined and grown in two saline conditions where carotenoid contents were increased and there is a consistency with the research reported by Durdu (2007). Leaf carotenoid contents were insignificantly decreased by application of calcium in saline conditions (Table 4). Yakıt and Tuna (2006) were also emphasized the similarities of the relationship between leaf carotenoid content and saline conditions and calcium application.

Table 4. The effects of calcium applications under saline conditions on chlorophyll a, chlorophyll b, total chlorophyll and carotenoid content of *L. sinuatum* plant

	***L. sinuatum* 'Compindi White' Chlorophyll and Carotenoid content**				***L. sinuatum* 'Compindi Deep Blue' Chlorophyll and Carotenoid content**			
Applications	**Chlorophyll a (mg/l YA)**	**Chlorophyll b (mg/l YA)**	**Total Chlorophyll (mg/l YA)**	**Carotenoid (mg/l YA)**	**Chlorophyll a (mg/l YA)**	**Chlorophyll b (mg/l YA)**	**Total Chlorophyll (mg/l YA)**	**Carotenoid (mg/l YA)**
Control soil	5.51	2.70	8.21	14.85	4.83	2.45	7.28	13.52
Saline soil	7.62	3.18	10.81	18.73	6.82	3.25	10.07	18.35
$LSD_{0.05}$	0.60**	0.27**	0.60**	2.38**	0.53**	0.38**	0.80**	2.27**
Control soil * 0 mM Ca	5.62	2.82	8.43	15.33	4.22	2.46	6.68	11.74
Control soil * 30 mM Ca	5.41	2.58	7.99	14.38	5.44	2.44	7.88	15.29
Saline soil * 0 mM Ca	6.66	2.75	9.42	20.06	6.66	3.24	10.32	18.65
Saline soil * 30 mM Ca	8.58	3.61	12.20	17.41	6.98	3.26	9.82	18.04
$LSD_{0.05}$	0.85**	0.39**	0.85**	n.s	n.s	n.s	1.13*	n.s

The amino acid proline is one of the most researched compounds in plant stress physiology. There are significant increases in proline under salt stress and water stress; this supports the stress resistance and the strength of the plant by bringing out the activation of the plant defense mechanism. The proline content increases in the plants under salt and water stress (Shannon, 1997). Under osmotic stress, proline acts as osmotic balancer, a reservoir for C and N to promote continued growth and source of energy; stabilizing the intracellular structure, a free radical repellent, an enzyme protector, a replacement substance for chlorophyll synthesis, and a stress signaling molecule (Tuna et al., 2005).

Türkan and Demiral (2009) have indicated that, in high salt concentrations especially in halophytes, proline is highly effective in balancing osmotic pressure while Türkan and Demiral (2009) explained the effect of proline regarding osmo tolerance in plants.

Proline contents significantly increased by 72.74 % (p=0.01) due to salinity, and 29.37 % significantly (p=0.05) decreased with the application of calcium under saline conditions in the 'Compindi White' cultivar. in the changes were more pronounced for the 'Compindi Deep Blue' due to salinity (significant increase; p=0.01) at 82.13 % and, calcium application under saline conditions significantly (p=0.01) decreased proline content by 43 % as could be expected (Table 5). The results are consistent with the results of other authors (Shannon, 1997; Türkmen et al., 2002; Tuna et al., 2005; Yakıt and Tuna, 2006; Köşkeroğlu, 2006; Durdu, 2007).

Destruction due to disturbed integrity of cell membranes, closing of stomates and disruption of photosynthetic electron transportation indicate oxidative-stress, resulting in the activation of the anti-oxidative defense mechanism. Hence, plants have specific anti-oxidant substances and anti-oxidative enzymes. The active oxygen derivatives cause lipid peroxidation, hence the cell membrane becomes destructed (Hermandez et al., 1994; Sreenivasulu et al., 2000; Dolatabadian et al., 2008). However, determination of the amount of malondialdehid (MDA), which is a product of lipid peroxidation, is the simplest way to determine the oxidative damage (Spychalla and Desborough, 1990; Jatgap and Bhargava, 1995).

To determine the amount of the damage in the cell due to salt stress, the changes in the amount malondialdehid (MDA), product of lipid peroxidation was measured. The measurements emphasized the very important changes in the cell.

Lipid peroxidation analyses showed that the changes in the amount of MDA in 'Compindi White' cultivar was 20.67 % (p=0.01), but this ratio was decreased by 24.56 % with calcium application under saline conditions compared to control conditions. In the same way, in 'Compindi Deep Blue' cultivar, the amount of MDA caused significant increase by 37.64 % (p=0.01), under saline conditions regarding control parcels, calcium application under saline conditions cause 20.16 % decrease in the amount of MDA. Leaf MDA changes due to the effects of calcium applications shown on the Table 5.

The results obtained from the researches, about the changes in the amount of MDA (product of lipid peroxidation), which showed deteriorations in the cell, showed itselves in the cell membrane caused by salt stress, are consistent with the results obtained from this research. When the restorative effect of calcium on the cell membranes is considered, consistency gains much more meaning (Kuşvuran et al., 2008).

Table 5. The effects of calcium applications on proline and malondialdehid (MDA) content of *L. sinuatum* plant under saline conditions

Applications	***Limoniu sinuatum* 'Compindi White'** Proline and MDA content		***Limoniu sinuatum* 'Compindi Deep Blue'** Proline and MDA content	
	Proline content (µmol/g)	**MDA content (nmol.ml^{-1})**	**Proline content (µmol/g)**	**MDA content (nmol.ml^{-1})**
Control soil	16.95	21.04	17.46	20.06
Saline soil	29.28	25.39	31.80	27.61
LSD$_{0.05}$	4.80**	4.13*	4.62**	7.15*
Control soil * 0 mM Ca Control soi	16.63	19.84	17.50	19.70
* 30 mM Ca	17.28	22.23	17.42	20.41
Saline soil * 0 mM Ca	34.32	28.95	40.51	30.70
Saline soil * 30 mM Ca	24.24	21.84	23.09	24.51
LSD$_{0.05}$	6.78*	n.s	6.53**	n.s

It is concluded that, calcium applications can be used as a strategy in order to increase tolerance against saline conditions in 'Compindi White' and 'Compindi Deep Blue' grown in saline conditions, when all the indications and results evaluated together. In the plant *L. sinuatum*, calcium applications increase the resistance to saline conditions and affect in a positive respect some stress parameters and flower performance. Like the other performed researches, calcium effect under saline conditions brings out very important results, especially in some stress parameters. Again like in some other researches that have similar results, there are decreases and fluctuations the results about yield.

CONCLUSION

An increasing number of studies mention requirements for fertilizer and especially plant nutrients in poor soils, while cultivation of *L. sinuatum*, gains in importance in ornamental plants and is a strong plant for poor soils, hence the studies of adaptation to arid and saline conditions become very important in every respect (Akat et al., 2010).

When the benefits of cut flower cultivation is taken into consideration;. increasing yield and reducing chemical fertilizers, gain importance (Verlinden and Mc Donald, 2007). In respect of climate and soil conditions of Turkey, it is concluded that cultivation of *L. sinuatum* provides an important contribution to the economy. In order to do this, there is need for research about how to increase the yield and quality (Akat et al., 2012). Studies on regular fertilization contain balanced ratios of nutrients, and show that the yield and quality of *L. sinuatum* plant increased significantly (Papadopoulos et al., 2006; Verlinden and Mc Donald, 2007).

Past results indicate that it is possible to cultivate the plant *L. sinuatum*. Nevertheless, in order to understand some stress parameters, i.e. proline, leaf relative water content (RWC), chlorophyll, carotenoid, lipid peroxidase, within the acceptable ranges in open-field farming, performing compulsory calcium applications additionally lowers the effects of stress parameters by changing the results into positive indicators. With respect to the properties of yield and quality, calcium applications should be carefully administered and monitored. In this research, 30 mM calcium application affected the stress parameters in a positive way. Further research is required to assess higher concentrations.

It is known that, there are natural species of *Limonium* in Mugla, Turkey where the research took place. On this land, having similar type of soil where these species grow and cannot be used in agricultural purposes, it will be possible to grow *L. sinuatum* species in open land. However, one of the recommendations is to provide positive effect in economy by the usage of naturally grown species in these type of lands. They are species which can also be easily used in xeroscape studies because of its resistance to salt and aridity.

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