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The Effect of Salinity and Fertilizer Applications on Leaf Nutrient Status and Some Quality Characteristics of *Ficus benjamina*

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Abstract: The effect of different N doses and salt levels on leaf N, P, K status and some quality parameters (leaf area, plant height and dry matter) was investigated in indoor plant of commercial importance, *Ficus benjamina* L. (weeping fig). A pot experiment was carried out in Ege University Faculty of Agriculture, Soil Science department greenhouse and it was setup the completely randomized design of 4 N doses and 4 salinity levels. N doses were 0 (N0), 100 (N1), 200 (N2), 300 (N3), 400 (N4) ppm from Ammonium nitrate (33%N). Salt levels were 0 (St0), 250 (St1), 500 (St2), 750 (St3), 1000 (St4) ppm from NaCl: $CaCl_2$ in a 1: 1 ratio. To conclude, leaf N, P, K content, leaf area, plant height and dry matter increased with increasing N doses and contrary decreased with increasing salt levels except leaf N content. Maximum leaf N P, K content and leaf area, plant height and leaf dry weight was found in N4-St4, N3-St0, N4-St2, N3-St0, N3-St2, N3-St1 levels, respectively. This finding also suggested that proper management of the salt concentrations of the growing media and irrigation water can provide an effective tool to improve the quality of *Ficus benjamina* with little effect on yield.

Key words: Salt stress, nitrogen nutrition, ornamental plants, balanced fertilization

INTRODUCTION

Decreasing of plant productivity from the excess of salinity is a worldwide problem. Recently studies have been conducted in order to determine the plant growth and yield response for many plants (Parida and Das, 2005; Kijne, 2006; Cortina and Macia-Culianez, 2005; Yamaguchi and Blumwald, 2005; Mahajan and Tuteja, 2005). They are focused on the control of the salt stress, determination of tolerance mechanism and finding new solutions at the molecular leveling plants. But the data in literature on stress are limited (Veneklaas and Ouden, 2005; Loh *et al*., 2003; Veneklaas *et al*., 2002, Tijskens *et al*., 1996) and are not on salt stress on *Ficus benjamina*.

The genus Ficus, is a member of the family Moracea and contains over 800 species. *Ficus benjamina* (weeping fig) is a tropical Asian evergreen tree; the weeping fig can reach 15 m in height. It has shiny, pointed, oval leaves, insignificant fruit and an invasive root system. This species and its cultivars are used extensively as potted house plant. It has moderate salt tolerance, and will grow in full sun and partial shade on any well drained-soil (Cheers, 1999; Gilman and Watson, 1993).

Cultivars in the *Ficus benjamina* species should not be fertilized if soluble salts are 640 ppm or more when solution is extracted by the pour-through method. Nutrient concentrations in leaves considered low, medium and high for *Ficus* growth as follows. Nitrogen (%) 1.40-1.79, 1.80-2.50, >2.5; P (%) 0.08-0.09, 0.10-0.50, > 0.50, K (%) 0.70-0.99, 1.00-2.00, > 2.00 (Alparslan *et al*., 2004).

Maintaining adequate nutrient elements in the growing media is a common goal in ornamental plant production, as it generally increased growth rates. Soil salinity, saline irrigation water and also the heavy use of fertilizer salts can severely restrict plant growth, cause foliage damage and even death of the plants. Therefore, salinity and sodicity can be serious problem in greenhouses. Most potted plants are rated as sensitive to salinity. The influence of salinity and nitrogen added to the nutrient solution, on productivity, photosynthesis and nitrogen metabolism has been studied in different plants (Gonzalez *et al*., 2002; Misra and Gupta, 2006; Bendixen *et al*., 2001; Hawkins and Lewis, 1993).

Limited numbers of ornamental plants have been tested for their salt tolerance. *Chrysanthemum*, carnation, and stock are considered moderately tolerant to salt stress; aster, poinsettia, gladiolus, azalea, gardenia, gerbera, amaryllis, and African violet are considered somewhat sensitive. Like other ornamental species, the esthetic value of floral plants is the determining factor for salt tolerance (Francois and Maas, 1999).

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This study aimed to evaluate the effects of different N doses in salt stress conditions on leaf N, P, K status, leaf area, plant height and leaf dry weight of *Ficus benjamina* and also to determine optimum nutritional status and quality characteristics in different salt levels.

MATERIALS AND METHODS

The experiment was carried out at the Ege University Faculty of Agriculture, Soil Science department greenhouse located Bornova district of Izmir, Turkey (38°27'18" N, 27°13'59 E). In all experiment, plants were grown individually in 75 buckets (9×9 cm) in a medium composed of peat, bark and perlite in a ratio of 3:1:1 (v/v) was used. Growing media samples were taken before planting and all their physico-chemical characteristics were determined according to conventional methods.

The experiment was included 0, 100, 200, 300, 400 ppm N doses from Ammonium nitrate (33%N), 0, 250, 500, 750, 1000 ppm salinity levels from $NaCl{:}CaCl_2$ in a 1:1 ratio, all treatments were arranged in the completely randomized design. There were 3 replications in all treatments, all were irrigated and other cultural amendments were done on time. Phosphorus and K fertilizers were added irrigation water at the constant rates 75 ppm P and 165 ppm K from $K_2CO_3 + KH_2PO_4$ for all applications.

Fully developed young leaves were collected in November which is recommended sampling (Alparslan *et al*., 2004). Leaf analyses were carried out on the homogenized sample oven dried at 65°C to constant weight and was analyzed according to Kacar (1972). Leaf area was measured using an Image Analyses System (FLAECHE computer software, Giessen, Germany).

The results of the analyses have been evaluated statistically (Little and Hills, 1978). The data were examined by the statistical package, TARIST (Açıkgöz *et al*., 1993).

RESULTS AND DISCUSSION

As it is seen on the Table 1, growing media were slightly acidic in reaction, low in EC and $CaCO_3$.

The separately effects of N doses and salinity levels were found statistically significant on all examined parameters except leaf N contents. Moreover, interactions between N doses and salinity levels were found statistically significant on leaf P content, leaf area and leaf dry weight. No statistically relationships were found between AxB interactions on leaf N, P content, leaf height (Table 2).

Table 3 shows the effect of N doses and salt levels on leaf nutrient element status. Plant N concentrations increased gradually and its uptake significantly with increasing N addition. In all salt levels, leaf N content increased significantly with increasing N doses. The highest leaf N was found at the highest N dose. Leaf P concentration increased with respect to increasing N treatments till 200 ppm N dose than showed decreasing trend for all salt levels except control and 500 ppm salt level. The highest leaf P was found in 300 ppm N doses in control (0 salts) and 500 ppm salt level than also showed decreasing trend. Leaf P and K content increased with increasing N doses for all salt levels. On the other hand, according to average values leaf P and K content decreased with increasing salt levels for N doses (Table 3).

The effect of N doses and salt levels on plant height, leaf area and leaf dry weight were shown in Table 4. As it can be seen from table leaf area increased with respect to increasing N treatments till 200 ppm N dose than showed decreasing trend for all salt levels except control and 750 ppm salt level. According to average values leaf area increased with increasing N doses and decreased with increasing salt levels. Similarly plant height and leaf dry weight was showed same trend with leaf area related with average values.

Leaf N and K contents were increased with increasing N doses. Increasing of N doses up to 300 ppm increased leaf P content, above leaf P content decreased. At most N doses, increasing salinity slightly increased leaf N, P and K contents (Table 3), on the other hand this is probably due to decreased dry weight (Table 4).

All parameters of growing media were found in optimum range for growing *Ficus benjamina* which was reported by Poole *et al*. (1981). The best growing media for *Ficus* plant is pH of 5.5-7.0, Sphagnum peat, pine bark, vermiculate or perlite can be volumetrically combined to

Table 1: Physico-chemical characteristics of the growing media

Properties	Results	Properties	Results
pH (25°C)	6.35	Available K (ppm)	78
EC (mm hos cm^{-1})	0.40	Available Ca (ppm)	167
$CaCO_3$ (%)	0.10	Available Mg (ppm)	37
Organic matter (%)	61.88	Available Na (ppm)	8
CEC* (%)	51	Available Fe (ppm)	2
Total N (%)	1.100	Available Cu (ppm)	0.05
Available P (ppm)	1	Available Zn (ppm)	0.20
*CEC = Cation Exchange Capacity		Available Mn (ppm)	0.35

Table 2: Results of analysis of variance

Source of Variance	Calculated F-value: N	P	K	Leaf area	Leaf height	Dry weight
N Doses (A)	210.86**	79.61**	192.77**	115.26**	167.31**	157.48**
Salt Levels (B)	1.60 ns	3.13*	5.80**	29.01**	11.82**	27.53**
AxB Interaction	0.44ns	2.74**	1.51ns	4.38**	1.44ns	3.81**

**,* = Statistically significant at p <0.01, p <0.05, respectively; ns = non significant

Table 3: The effect of N doses and salt levels on leaf nutrient status

Leaf N (%)	N doses (ppm)					
Salt Levels (ppm)	0	100	200	300	400	Average
0	1.530	3.020	3.210	3.520	3.600	2.976
250	1.580	3.130	3.230	3.470	3.650	3.012
500	1.610	3.170	3.280	3.410	3.730	3.040
750	1.650	3.300	3.300	3.410	3.870	3.106
1000	1.730	3.350	3.320	3380	4.000	3.156
Average	1.620d	3.194c	3.268bc	3.438b	3.370a	
LSD (0.01)	N Doses = 0.217	Salt Levels = ns	N×Salt = ns			
Leaf P (ppm)	0	100	200	300	400	Average
0	0.230cAB	0.320bA	0.340abA	0.390aA	0.323bA	0.321A
250	0.250bAB	0.290bA	0.360aA	0.350aAB	0.280bAB	0.306AB
500	0.220bAB	0.270bA	0.360aA	0.370aAB	0.260bB	0.296B
750	0.260bA	0.320aA	0.350aA	0.330aB	0.250bB	0.302B
1000	0.200bcB	0.290bA	0.370aA	0.360aAB	0.243bcB	0.298B
Average	0.232d	0.298b	0.356a	0.360a	0.271c	
LSD	N Doses(0.01) = 0.230		Salt Levels (0.05) = 0.018		N×Salt (0.01) = 0.052	
Leaf K (%)	0	100	200	300	400	Average
0	1.830	2.100	2.280	2.570	2.600	2.276A
250	1.780	2.040	2.320	2.480	2.580	2.240AB
500	1.700	2.170	2.410	2.580	2.610	2.294A
750	1.950	2.100	2.350	2.520	2.480	2.280A
1000	1.680	2.020	2.210	2.460	2.420	2.158B
Average	1.788d	2.086c	2.134b	2.522a	2.538a	
LSD (0.01)	N Doses = 0.086	Salt Levels = 0.086	NxSalt = ns			

Different small letters in the same row means that N treatments differ significantly. Different capital letters in the same column means that salt treatments differ significantly

Table 4: The effect of N doses and salt levels on some quality parameters

Leaf area (cm^2)	N doses (ppm)					
Salt levels (ppm)	0	100	200	300	400	Average
0	215dA	417cB	510abA	589aA	456bcA	437.4A
250	250bAB	509aA	530aA	516aAB	363aB	433.6A
500	232cAB	368bBC	475aAB	474aBC	432abAB	396.2B
750	205cA	325bC	400abBC	410aCD	400abAB	348.0C
1000	200bB	315aC	380aC	370aD	360aB	325.0C
Average	220.4c	386.8b	459.0a	471.8a	402.2 b	
LSD (0.01)	N doses = 35.430	Salt levels = 35.430	N×Salt =7 9.225			
Plant height (cm)	0	100	200	300	400	Average
0	31	33	50	60	61	47.0A
250	32	36	48	59	58	46.6A
500	31	36	42	61	57	45.4AB
750	30	34	42	53	53	42.4BC
1000	30	24	40	51	51	39.2C
Average	30.8c	32.6c	44.4b	56.8a	56.0a	
LSD (0.01)	N doses = 3.622	Salt levels = 3.622	N×Salt = ns			
Dry weight (g)	0	100	200	300	400	Average
0	1.40bA	1.72bA	2.77aA	3.16aA	2.93aA	2.396A
250	1.45bA	1.65bA	2.71aA	2.83 aAB	2.74 aA	2.276A
500	1.36cA	1.52cA	2.41abAB	2.73aBC	2.25bB	2.054B
750	1.30cA	1.40cA	2.21bB	2.80 aBC	1.90 bBC	1.922BC
1000	1.25bA	1.40bA	2.27aB	2.40aC	1.50bC	1.764C
Average	1.352e	1.538d	2.474b	2.784a	2.264c	
LSD (0.01)	N doses = 0.185	Salt levels = 0.185	N×Salt=0.414			

formulate media (Soyergin *et al*., 1994). According to properties of growing media is suitable for *Ficus* growing.

The effects of N doses were found dominant on all examined parameters than salinity levels. On the other hand effects of salt levels were found dominant on quality parameters than leaf nutrient status. Interactions between N doses and salt levels were depended on leaf P content, leaf area and dry weight indicates that, change in one of treatments may affect leaf P content, leaf area and dry weight (Table 2). Confirming trends were obtained by Campos and Reed (1994).

The results of leaf analyses were examined according to the limit values which have been set for *Ficus benjamina* by researchers as Alparslan *et al*. (2004). Nitrogen contents of leaves were found higher than sufficiency level except N dose. Phosphorus and K content of leaves were found sufficient in all N doses and salt levels compared with limit values.

The highest total N in leaves was found at highest level of salt and N doses. In accordance with the data in (Table 3) salt stress conditions was independent to N doses. It was reported that the reduction and assimilation of N were not significantly affected by salinity. Lewis *et al.* (1989) suggested that NH_4^+ supplied plants are more susceptible to salinity stress due to the fact that the assimilation of NH_4^+ taken up from the medium is curtailed under salinity since most available energy is required for osmoregulation.

One advantage of applied P over other nutrients is that once it is absorbed and retained in the soil-plant system and it is not subject to the large doses by leaching that occur with N and K fertilizers. Grattan and Grieve (1999) pointed out that Cl^- reduce P uptake. In other cases, a reduction in plant P concentration by salt levels may result from the reduced activity of P in the growing media solution due to the high ionic strength of the media. Results are in agreement with data presented by Sharpley *et al.* (1992) who have stated phosphate availability is reduced in saline conditions not only because of ionic strength effects that reduce the activity of P but also because P concentrations in growing media solution are tightly controlled by sorption processes and by the low solubility of Ca-P minerals.

Under saline conditions uptake of K routes may be affected. Salt stress is known to significantly reduce K uptake related with reduce intracellular K concentration especially in the vacuolar pool of barley leaves (Cuin *et al.*, 2003). The NaCl-induced uptake of K observed in our experiment may be result of such depletion of K at the molecular level. Potassium concentration in plant tissue has been reported to reduce as Na salinity in the root media increased (Grattan and Grieve, 1999).

Maximum leaf area was found at 300 ppm N and 0 salt levels; a further increase in salinity inhibits leaf area (Table 4). This behavior confirms that, in general, the first symptom of salt stress in plants is a restriction in leaf expansion (Matsuda and Riazi, 1981). Effect of salt stress conditions it is known that the reduction in total leaf area can be explained by a decrease in leaf turgor, changes in cell wall properties or a decreased photosynthesis rate (Franco *et al.*, 1997).

Experimental evidence shows that in a salt stress *F. benjamina* the plant growth is optimal at 200 ppm N dose and 250 ppm salt level, whereas further increase in salt level retards plant height. Increased salt levels results in a significant decrease in dry weight (Table 4). Salt stress results in a considerable decrease in the leaf dry weight (Alidinar *et al.*, 1999; Chartzoulakis and Klapaki, 2000).

Recent advances propose to manage nutrition on the basis of salt stress conditions give opportunities to develop balanced fertilization programs for *F. benjamina*. This practice made possible determination of the optimum N doses without salt injury. From the viewpoint of *Ficus* production, it means that 250 ppm salt level is the starting point limiting growth and therefore high salt inputs are reduce qualities of *F. benjamina*.

In practice, depend on our results, ficus fertilization can be optimized in accordance with expectations on balanced nutrition, quality or salt stress. Also the results are allow to estimation of nutrient availability and quality characteristics. It is recommended that using with on-line sensors (pH-E.C) to monitor ion concentrations, which make possible management of production without any injury.

Overall, results of present study are in agreement with earlier researches that *F. benjamina* salt stress conditions was independent N doses. In this respect, the fact that increase of N levels in salinity, could be related to higher effects of N doses than salinity levels, but in spite of this, other parameters were decreased in increase of salinity. Also it can be concluded that in P content in *Ficus benjamina* leaves decreased as salinity ($NaCl+CaCl_2$) increased. Decreasing in the K uptake in *Ficus* by Na^+ is a competitive processes and occurs regardless of whether the solution is dominated by Na^+ salts of Cl^- or SO_4^{-2} . The present research will serve as an important basis for future research designed to determine the levels of N doses and salt stress in *Ficus* production.

CONCLUSIONS

The results of the experiment that the plants did not present any perceptible symptoms nutrient deficiency; neither did the level of salt accumulation seem to cause any toxic effect to *Ficus*. Thus maximum salt level in this study was 1000 ppm which is lower when compared maximum level of 1283 ppm describe as causing toxicity symptoms (Chen *et al.*, 2003). On the other hand especially quality parameters decreased with increasing salt levels. All parameters increased with increasing N doses and decreased with increasing salt levels associated with average values.

Nutritional status of *Ficus*, expressed leaf nutrient contents may be affected by salinity induced nutritional disorders which is also may develop on *Ficus* from the effect of salt stress on nutrient elements availability, competitive uptake, transport, or partitioning within the plant.

The research was conducted on growing media moderate in N. Therefore, applications of N doses improved growth and quality characteristics degree of salinity was not severe. Applied N doses did not improve the determined parameters under high salinity levels suggest that applied N doses decreased salt tolerance of *Ficus benjamina*. Plants grown on low nutrient element content of growing media, may appear to be more salinity tolerance than those grown with adequate nutrient applied growing media. Due to inadequate plant nutrient applications depresses yields or quality characteristics more under nonsaline under saline conditions.

So the results revealed that N applications exceeding on nonsaline growing media do not to increase the salt tolerance of *Ficus benjamina*. Unless salinity causes certain nutritional deficiencies, excess applications of N fertilizer rarely alleviate the inhibition of growth by salinity. In fact, additional N dose adds to the salinity effect already present in the growing media and may aggravate salt injury.

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