*Iran Agricultural Research 11:51-67 (1992)*

# GROWTH AND CHEMICAL COMPOSITION OF THREE PISTACHIO CULTIVARS AS AFFECTED BY SOIL SALINITY AND BORON FERTILIZATION

*A.R. SEPASKHAH AND M. MAFTOUN*[1]

Departments of Irrigation and Soil Science, Shiraz University, Shiraz, Iran.

Paper No. K-588-71

*(Received March 17, 1992)*

## ABSTRACT

The effects of salinity and Boron (B) addition on the growth and chemical composition of three pistachio (*Pistacia vera* L.) cultivars, Badami, Fandoghi and Kale-ghoochi were studied in greenhouse. Pistachio seedlings were exposed to NaCl levels of 0, 1600, 3200 and 4800 µg per g dry soil and B rates of 0 to 50 µg per g dry soil. Shoot and root dry weights decreased with increasing NaCl levels. However, shoot growth suppression was more pronounced at the higher NaCl levels and was less severe with Kale-ghoochi than cultivars other. Shoot and root growth was generally reduced with B addition at 0 and/or 1600 $\mu g\ g^{-1}$ NaCl. Boron addition significantly increased the shoot B concentration and uptake. Furthermore, the cultivars exhibited unequal capacity to accumulate B. Shoot Cl and Na concentrations and Cl uptake were increased by increasing NaCl level. Based on the relation between 50% shoot growth reduction and shoot B concentration, it could be concluded that in non-saline soil, Badami is more sensitive to excess B than Fandoghi and Kale-ghoochi, whereas under high salinity, Fandoghi is more tolerant to excess B than Kale-ghoochi.

---

*1- Professors of irrigation and soil science, respectively.*

تحقیقات کشاورزی ایران
(۱۳۷۱) ۶۷-۱۱:۵۱

# تاثیر شوری خاک و بُر بر رشد و ترکیب شیمیایی سه رقم پسته

**علیرضا سپاسخواه و منوچهر مفتون**
به ترتیب استادان بخش آبیاری و بخش خاکشناسی دانشکده کشاورزی دانشگاه شیراز، شیراز، ایران

## چکیده

تاثیر شوری خاک و بُر بر رشد و ترکیب شیمیایی سه رقم پسته ( بادامی، فندقی و کله‌قوچی ) در یک آزمایش گلخانه‌ای مورد مطالعه قرار گرفت. نهالهای پسته در معرض صفر، ۱۶۰۰، ۳۲۰۰ و ۴۸۰۰ میکروگرم کلرور سدیم و صفر، ۱۰، ۲۰، ۳۰، ۴۰ و ۵۰ میکروگرم بُر در هر گرم خاک قرار داده شد. با افزایش میزان کلرور سدیم، وزن خشک ریشه و قسمت هوایی کاهش یافت اما کاهش رشد قسمت هوایی پسته در سطوح بالاتر کلرورسدیم بیشتر مشهود بود و این کاهش در کله قوچی در مقایسه با دو رقم دیگر کمتر بود. تاثیر سوء بُر بر وزن خشک قسمت هوائی و ریشه پسته فقط در سطوح صفر، ویا ۱۶۰۰ میکروگرم کلرور سدیم در هر گرم خاک مشاهده گردید. مصرف بُر معمولاً با افزایش معنی‌دار در غلظت و جذب کل بُر همراه بوده، بعلاوه تفاوتهای مشخصی در بین ارقام در رابطه با تجمع بُر دیده شد. غلظت کلرور و سدیم و جذب کل کلرور با افزایش سطوح کلرورسدیم افزایش یافت. برمبنای رابطه میان ۵۰ درصد کاهش رشد قسمت هوائی گیاه و غلظت بُر می‌توان نتیجه گرفت که در خاکهای غیرشور، بادامی در مقایسه با فندقی و کله‌قوچی به زیادی بُر حساستر است، حال آنکه در خاکهای زیاد شور، مقاومت فندقی به بُر بیشتر از کله‌قوچی است.

## INTRODUCTION

Pistachio (*Pistacia vera* L.) is an important horticultural crop in Iran, with an estimated number of more than 13 million trees. Presently, some regions of commercial production are contented with salinity problems (14).

Moreover, soluble borates tend to accumulate in soils of these areas and often reach levels limiting normal plant growth. Although, the effects of B and/or soil salinity on the growth and chemical composition of pistachio has been recently studied (9, 10, 11, 12, 13, 14), the authors are not aware of any published report regarding the interaction of soil salinity and B treatment on the growth and development of this crop. Therefore, the present study was initiated to evaluate the combined effects of several NaCl levels and B rates on the growth and chemical composition of three local pistachio cultivars in a calcareous soil.

## MATERIALS AND METHODS

A bulk sample of an alluvial calcareous silty clay soil (Calcixerollic Xerochrept) was collected from the Ap horizon from the vicinity of Badjgah Agricultural Experiment Station, 16 km north of Shiraz, Iran. Some physico-chemical characteristics of this soil have been described earlier (11). The soil contains 0.31 μg B $ml^{-1}$ in saturation extract. The air-dried soil was crushed to pass a 2-mm screen. The treatments consisted of three pistachio cultivars (Badami, Fandoghi and Kale-ghoochi), four levels of NaCl (0, 1600, 3200 and 4800 μg per g dry soil) and six rates of B (0, 10, 20, 30, 40 and 50 μg per g dry soil). Boron was added as aqueous solution of boric acid to 4 kg of soil in plastic bags. Two weeks after the addition of B, the soil in each bag was thoroughly mixed, then before planting poured into a plastic pot with a drainage hole.

Pistachio seeds were placed in muslin sacks and soaked in distilled water for 24 h. Ten seeds were then pre-treated with 0.4% captan solution and planted in each pot. When the plants were six weeks old, salt treatments were imposed by adding aqueous solution of NaCl to the soil. Desired NaCl levels were added in two equal parts on a 10-day interval. Seedlings were thinned out to three per pot after nine weeks. Nitrogen and

P were applied uniformly to all pots at the rate of 50 μg $g^{-1}$ each, as reagent grade $NH_4NO_3$ and $KH_2PO_4$, respectively.

The experimental design was a completely randomized with treatment combinations arranged in a factorial manner using three replicate. Pots were irrigated periodically with distilled water to near field capacity by weight with no leaching of salts from pots. The seedlings were grown from March to October in a greenhouse with average day and night temperatures of 34 and 14°C, respectively.

At the end of experimental period, the plants were harvested and separated into shoot and root fractions. Roots were removed by washing the entire bulk of soil from each pot on a 35-mesh sieve under running tap water. They were further washed with distilled water. Shoots and roots were dried at 70°C for 48 h, dry weights were recorded, and the tissues were ground in a Wiley mill to pass a 40-mesh screen. Chloride was measured by the method outlined by Chapman and Pratt (2). Boron determinations were made by the curcumin procedure of Dible *et al.* (4). Representative samples of shoots were dry-ashed and analyzed for Na by EEL flame photometry. Nutrient uptakes were calculated by multiplying weight of top dry matter per pot by nutrient concentration.

## RESULTS AND DISCUSSION

Analysis of variance for the main effects of B and NaCl levels and their interaction for growth responses and shoot chemical composition are shown in Table 1.

### Growth

Shoot and root dry weights of the three pistachio cultivars as affected by B and NaCl levels are shown in Tables 2 and 3. Shoot and root dry weights decreased with increasing NaCl levels. This is in agreement

Table 1. Analysis of variance for various growth responses and chemical composition of three pistachio cultivars under four levels of NaCl and six rates of soil applied boron.

| Source | df | Dry weight | | B in shoot | | Cl in shoot | |
|---|---|---|---|---|---|---|---|
| | | Shoot | Root | Concentration | Uptake | Concentration | Uptake |
| | | | | Badami | | | |
| NaCl(S) | 3 | 1140.70** | 135.10** | 2092.8** | 1.467** | 27.20 | 3708.8** |
| Boron(B) | 5 | 21.70** | 6.73** | 12257.5** | 0.510** | 0.87 | 169.6 |
| S × B | 15 | 7.43** | 3.07** | 1147.0** | 0.110** | 0.54 | 296.5 |
| Error | 48† | 2.55 | 1.00 | 90.2 | 0.010 | 0.19 | 290.5 |
| | | | | Fandoghi | | | |
| NaCl(S) | 3 | 1240.20** | 89.70** | 2381.7** | 3.91** | 45.30** | 7919.1** |
| Boron(B) | 5 | 12.00* | 6.37** | 17877.7** | 1.04** | 2.50** | 472.3 |
| S × B | 15 | 4.65 | 1.71 | 675.1** | 0.32** | 2.30** | 431.7 |
| Error | 48 | 3.97 | 1.55 | 277.8 | 0.07 | 0.35 | 430.2 |
| | | | | Kale-ghoochi | | | |
| NaCl(S) | 3 | 1398.50** | 157.70** | 1160.0 | 4.30** | 32.40* | 25149.2** |
| Boron(B) | 5 | 36.50** | 16.90** | 10123.0 | 0.79** | 0.16** | 5328.3** |
| S × B | 15 | 9.11** | 1.97 | 194.9 | 0.34** | 0.83** | 3597.8** |
| Error | 48 | 3.24 | 1.73 | 18.6 | 0.10 | 0.02 | 1022.7 |

*, ** Significant at p=0.05 and 0.01, respectively.

† The degree of freedom is 48 for all growth criteria except for Cl concentration and Cl uptake which is 47, 45 and 43 for Badami, Fandoghi and Kale-ghoochi, respectively.

Table 2. Effects of added NaCl and B on shoot dry weight (g $pot^{-1}$) of three pistachio cultivars.

| Added B (µg/g dry soil) | Added NaCl (µg/g dry soil) | | | | |
|---|---|---|---|---|---|
| | 0 | 1600 | 3200 | 4800 | Mean |
| | | | Badami | | |
| 0 | 21.0 a* | 14.3 b | 3.0 a | 1.9 a | 10.1 ab |
| 10 | 19.8 ab | 18.2 a | 4.7 a | 2.1 a | 11.2 a |
| 20 | 20.3 ab | 12.0 bc | 4.3 a | 1.8 a | 9.6 b |
| 30 | 17.7 bc | 15.0 b | 3.1 a | 2.1 a | 9.8 b |
| 40 | 16.4 c | 13.8 bc | 3.1 a | 2.3 a | 8.9 b |
| 50 | 13.6 d | 11.4 c | 2.1 a | 1.5 a | 7.2 c |
| Mean | 11.1 A | 14.1 B | 3.4 C | 1.9 D | |
| | | | Fandoghi | | |
| 0 | 19.8 ab | 14.2 a | 5.8 a | 1.8 a | 10.4 ab |
| 10 | 21.7 a | 16.5 a | 5.3 a | 2.7 a | 11.6 a |
| 20 | 20.4 a | 16.4 a | 2.4 ab | 2.0 a | 10.7 a |
| 30 | 18.2 abc | 15.5 a | 5.5 a | 2.3 a | 10.4 ab |
| 40 | 17.0 bc | 15.0 a | 3.8 ab | 1.5 a | 9.8 ab |
| 50 | 16.0 c | 16.4 a | 1.3 b | 1.5 a | 8.8 b |
| Mean | 18.8 A | 15.6 B | 4.3 C | 2.0 D | |
| | | | Kale-ghoochi | | |
| 0 | 19.1 a | 17.7 ab | 6.1 b | 2.0 a | 11.2 b |
| 10 | 23.2 a | 19.7 a | 5.6 bc | 2.2 a | 12.7 a |
| 20 | 19.7 b | 20.6 a | 10.0 a | 2.0 a | 13.1 a |
| 30 | 19.8 b | 13.0 c | 2.8 cd | 1.7 a | 9.3 cd |
| 40 | 19.7 b | 16.1 bc | 3.9 bcd | 1.8 a | 10.4 bc |
| 50 | 18.1 b | 13.9 c | 1.7 d | 1.5 a | 8.8 d |
| Mean | 19.9 A | 16.8 B | 5.0 C | 1.9 D | |

* Means followed by the same letter within each column (lower case letters) and the row (capital letters) for each cultivar are not significantly different at P=0.05 as determined by Duncan's multiple range test.

Table 3. Effects of added NaCl and B on root dry weight (g $pot^{-1}$) of three pistachio cultivars.

| Added B (µg/g dry soil) | Added NaCl (µg/g dry soil) | | | | |
|---|---|---|---|---|---|
| | 0 | 1600 | 3200 | 4800 | Mean |
| | | | Badami | | |
| 0 | 8.67 a | 6.37 b | 2.97 a | 0.90 a | 4.73 a |
| 10 | 7.27 abc | 8.57 a | 3.13 a | 0.70 a | 4.92 a |
| 20 | 8.27 ab | 4.17 c | 3.03 a | 1.33 a | 4.20 ab |
| 30 | 5.57 cd | 5.23 bc | 2.50 a | 0.83 a | 3.53 bc |
| 40 | 6.57 bc | 6.23 b | 2.70 a | 0.97 a | 4.12 ab |
| 50 | 4.83 d | 4.13 c | 1.87 a | 0.80 a | 2.91 c |
| Mean | 6.86 A | 5.78 B | 2.70 C | 0.92 D | |
| | | | Fandoghi | | |
| 0 | 6.77 a | 6.73 a | 1.97 a | 0.57 a | 4.01 a |
| 10 | 6.00 ab | 5.67 ab | 1.20 a | 0.87 a | 3.43 ab |
| 20 | 4.93 abc | 3.70 b | 1.83 a | 0.87 a | 2.83 bc |
| 30 | 4.40 bc | 5.20 ab | 2.40 a | 0.80 a | 3.20 ab |
| 40 | 3.77 c | 4.37 b | 1.07 a | 0.43 a | 2.41 bc |
| 50 | 2.93 c | 4.20 b | 0.37 a | 0.43 a | 1.97 c |
| Mean | 4.80 A | 4.98 A | 1.47 B | 0.66 B | |
| | | | Kale-ghoochi | | |
| 0 | 7.87 a | 8.87 ab | 2.37 ab | 2.10 a | 5.30 a |
| 10 | 7.80 a | 9.43 a | 2.77 ab | 1.20 a | 5.30 a |
| 20 | 6.17 abc | 6.83 bc | 3.83 a | 1.23 a | 4.52 b |
| 30 | 6.43 ab | 5.70 c | 1.50 ab | 0.67 a | 3.58 bc |
| 40 | 5.00 bc | 5.77 c | 1.13 b | 0.70 a | 3.15 cd |
| 50 | 4.03 c | 4.97 c | 0.40 b | 0.30 a | 2.43 d |
| Mean | 6.22 A | 6.93 A | 2.00 B | 1.03 C | |

* Means followed by the same letter within each column (lower case letters) and the row (capital letters) for each cultivar are not significantly different at P=0.05 as determined by Duncan's multiple range test.

with results reported by others (8, 9, 11, 13, 14). However, shoot growth suppression was more pronounced at the NaCl levels and it generally was less severe with Kale-ghoochi than Badami and Fandoghi. In spite of shoot growth reduction, no shoot injury was observed. There was a general trend for a decrease in shoot and root dry weights of the three cultivars with increasing B levels at 0 and 1600 μg $g^{-1}$ NaCl (Tables 2 and 3). Boron addition generally had no significant effect on the shoot and root dry weights of the three pistachio cultivars at the higher NaCl levels. This was propably due to the fact that plant growth was severely suppressed at these levels of salinity and consequently B addition could not further aggravate the problem.

In the present study, it seems that shoot growth suppression of Kale-ghoochi due to 50 μg B $g^{-1}$ was least at 0 salinity level and became greatest at 4800 μg NaCl $g^{-1}$.

## Chemical Composition

Boron addition significantly increased the shoot B concentration of the three cultivars (Table 4). Furthermore, the pistachio cultivars exhibited a variable capacity to accumulate B from B fertilization. Mean shoot B concentration of Fandoghi and Kale-ghoochi generally declined with increasing NaCl levels (Table 4). A decrease in B concentration with increasing salinity has also been reported by Chauhan *et al.*(3) in linseed. This was especially true at 20 μg B $g^{-1}$ or higher rates.

Mean shoot Cl concentration of the three cultivars increased significantly with NaCl application (Table 5). Furthermore, Fandoghi accumulated higher Cl than the others especially at the highest NaCl level. The salt sensitivity of many cultivars is associated with the accumulation of excessive concentration of Cl and sometimes Na in leaves (5). Mean shoot Na concentrations of the three cultivars primarily increased as a function of soil salinity and B addition had no effect on Na accumulation (Table 6). Moreover, the shoot Cl concentration was higher than that of Na

Table 4. Effects of added NaCl and B on the B concentration (µg/g dry wt. basis) in shoot tissues of three pistachio cultivars.

| Added B (µg/g dry soil) | Added NaCl (µg/g dry soil) | | | | |
|---|---|---|---|---|---|
| | 0 | 1600 | 3200 | 4800 | Mean |
| | | | Badami | | |
| 0 | 17.2 e* | 12.6 d | 8.3 d | 11.7 e | 12.5 f |
| 10 | 25.5 cd | 12.2 d | 8.3 d | 24.2 d | 17.5 e |
| 20 | 18.5 de | 24.2 c | 24.2 c | 31.7 c | 24.6 d |
| 30 | 26.9 c | 31.1 c | 24.2 c | 56.0 b | 34.6 c |
| 40 | 62.0 b | 58.8 b | 48.1 b | 87.5 a | 64.1 b |
| 50 | 91.7 a | 91.4 a | 70.8 a | 89.7 a | 85.9 a |
| Mean | 40.3 B | 38.4 B | 30.6 C | 50.1 A | |
| | | | Fandoghi | | |
| 0 | 8.3 | 10.0 c | 8.3 c | 12.2 c | 9.7 d |
| 10 | 18.3 d | 19.3 bc | 15.0 c | 21.2 c | 18.5 cd |
| 20 | 54.7 c | 20.2 bc | 25.0 bc | 16.8 c | 29.2 c |
| 30 | 69.2 bc | 26.8 bc | 24.2 bc | 59.6 b | 44.9 b |
| 40 | 84.4 b | 43.6 b | 51.4 b | 42.8 b | 55.6 b |
| 50 | 130.6 a | 78.4 a | 137.3 a | 120.6 a | 116.7 a |
| Mean | 60.9 A | 33.1 C | 43.5 BC | 45.5 B | |
| | | | Kale-ghoochi | | |
| 0 | 16.8 d | 16.3 c | 13.5 c | 15.8 c | 15.6 e |
| 10 | 26.5 d | 21.7 bc | 22.7 c | 21.7 bc | 23.1 e |
| 20 | 47.2 c | 23.0 bc | 27.2 c | 30.0 bc | 31.8 d |
| 30 | 63.8 b | 38.4 b | 25.0 c | 37.3 b | 41.1 c |
| 40 | 69.6 b | 55.6 a | 58.1 b | 71.4 a | 63.7 b |
| 50 | 137.3 a | 60.4 a | 146.7 a | 63.2 a | 101.9 a |
| Mean | 60.2 A | 35.9 C | 48.9 B | 39.9 C | |

* Means followed by the same letter within each column (lower case letters) and the row (capital letters) for each cultivar are not significantly different at P=0.05 as determined by Duncan's multiple range test.

Table 5. Effects of added NaCl and B on the Cl concentration (% dry wt. basis) in shoot tissues of three pistachio cultivars.

| Added NaCl (µg/g dry soil) | Added B (µg/g dry soil) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 10 | 20 | 30 | 40 | 50 | Mean |
| | | | | Badami | | | |
| 0 | 0.15 c* | 0.18 c | 0.22 c | 0.22 c | 0.19 c | 0.20 c | 0.19 c |
| 1600 | 0.49 c | 0.42 c | 0.45 c | 0.41 c | 0.54 c | 0.58 c | 0.48 c |
| 3200 | 1.22 b | 1.35 b | 1.28 b | 1.98 b | 1.79 b | 1.62 b | 1.54 b |
| 4800 | 2.29 a | 2.34 a | 2.41 a | 3.45 a | 2.53 a | 4.42 a | 2.91 a |
| Mean | 1.04 C | 1.07 C | 1.09 C | 1.52 AB | 1.26 BC | 1.07 A | |
| | | | | Fandoghi | | | |
| 0 | 0.13 c | 0.27 b | 0.28 b | 0.26 b | 0.26 c | 0.26 c | 0.24 c |
| 1600 | 0.59 bc | 0.73 b | 0.61 b | 0.69 b | 0.56 c | 0.53 c | 0.62 c |
| 3200 | 1.27b | 1.14 b | 1.21 b | 1.24 b | 2.03 b | 5.11 a | 2.00 b |
| 4800 | 4.84 a | 3.39 a | 2.55 a | 4.56 a | 4.28 a | 3.68 b | 3.88 a |
| Mean | 1.07 C | 1.38 BC | 1.16 C | 1.69 B | 1.78 B | 2.40 A | |
| | | | | Kale-ghoochi | | | |
| 0 | 0.13 d | 0.27 d | 0.33 c | 0.18 c | 0.19 d | 0.14 d | 0.21 d |
| 1600 | 0.58 c | 0.55 c | 0.47 c | 0.70 b | 0.40 c | 0.59 c | 0.55 c |
| 3200 | 1.39 b | 1.61 b | 2.57 b | 2.87 a | 3.48 a | 3.45 a | 2.56 b |
| 4800 | 3.74 a | 3.16 a | 3.16 a | 2.73 a | 2.49 b | 2.46 b | 2.96 a |
| Mean | 1.46 B | 1.40 B | 1.64 A | 1.62 A | 1.64 A | 1.66 A | |

* Means followed by the same letter within each column (lower case letters) and the row (capital letters) for each cultivar are not significantly different at P=0.05 as determined by Duncan's multiple range test.

Table 6. Effects of added NaCl and B on the Na concentration (% dry wt.) in the shoot tissues of the three pistachio cultivars.

| Added NaCl (µg/g dry soil) | Added B (µg/g dry soil) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 10 | 20 | 30 | 40 | 50 |
| | | | Badami | | | |
| 0 | 0.014 ± 0.003 | 0.009 ± 0.011 | 0.001 ± 0.002 | 0.014 ± 0.000 | 0.014 ± 0.000 | 0.13 ± 0.003 |
| 1600 | 0.89 ± 0.019 | 0.78 ± 0.019 | 0.102 ± 0.026 | 0.100 ± 0.029 | 0.152 ± 0.052 | 0.127 ± 0.037 |
| 3200 | 0.455 ± 0.043 | 0.380 ± 0.041 | 0.483 ± 0.083 | 0.423 ± 0.059 | 0.633 ± 0.067 | † |
| 4800 | 1.195 ± 0.036 | 1.033 ± 0.048 | † | 1.313 ± 0.107 | 1.025 ± 0.086 | 2.164 ± 0.056 |
| | | | Fandoghi | | | |
| 0 | 0.011 ± 0.000 | 0.011 ± 0.001 | 0.011 ± 0.001 | 0.013 ± 0.001 | 0.010 ± 0.000 | 0.016 ± 0.002 |
| 1600 | 0.101 ± 0.023 | 0.138 ± 0.074 | 0.082 ± 0.015 | 0.123 ± 0.029 | 0.108 ± 0.050 | 0.095 ± 0.006 |
| 3200 | 0.552 ± 0.024 | 0.432 ± 0.069 | 0.050 ± 0.013 | 0.617 ± 0.022 | 0.333 ± 0.015 | † |
| 4800 | 2.85 ± 0.240 | 1.887 ± 0.244 | † | 1.700 ± 0.433 | 2.227 ± 0.153 | † |
| | | | Kale-ghoochi | | | |
| 0 | 0.012 ± 0.001 | 0.011 ± 0.001 | 0.012 ± 0.002 | 0.011 ± 0.002 | 0.011 ± 0.001 | 0.013 ± 0.004 |
| 1600 | 0.102 ± 0.029 | 0.104 ± 0.041 | 0.058 ± 0.003 | 0.058 ± 0.008 | 0.067 ± 0.023 | 0.072 ± 0.009 |
| 3200 | 0.568 ± 0.174 | 0.034 ± 0.007 | 0.044 ± 0.006 | † | 0.123 ± 0.063 | † |
| 4800 | 1.707 ± 0.463 | 0.497 ± 0.017 | † | 0.967 ± 0.281 | 2.017 ± 0.317 | † |

† Due to inadequate dry matter, it was not possible to determine Na concentration.

at each salinity and for each cultivar. However, the magnitude of this difference diminishes with each increase in applied NaCl concentration. In other words, the shoot Na concentrations were only slightly less than Cl concentrations at the highest salinity. This is in agreement with the findings of Maftoun *et al.* (7) in soybean (*Glycine max* L. Merr.) and Sepaskhah and Maftoun (11) in pistachio. Lessani and Marschner (6) reported that the Cl concentration varied in various salt-stressed crops, excepting sugar beet (*Beta vulgaris* L.) where Cl concentrations were always higher than Na. Bernal *et al.* (1) suggested that the higher Cl than Na uptake in salt-stressed crops could be responsible for growth suppression by reducing the uptake of $NO_3$-N.

Boron fertilization enhanced shoot B uptake by the three cultivars at four salinity levels (Table 7). However, an increase in B uptake was more pronounced at 0 and 1600 µg NaCl $g^{-1}$ and Fandoghi and Kale-ghoochi accumulated more B than did Badami at 20 or higher µg B $g^{-1}$. Shoot B uptake was suppressed with NaCl addition (Table 7). Salinity up to 1600 µg NaCl $g^{-1}$ significantly increased the shoot Cl uptake by the three cultivars (Table 8). Higher salinity reduced the Cl uptake. However, in Kale-ghoochi, increasing NaCl level up to 3200 µg $g^{-1}$ generally increased the shoot Cl uptake.

## Relative Growth Analysis

Attempts were made to evaluate relative shoot growth with respect to shoot B concentration of the three pistachio cultivars at 0, 1600, 3200 and 4800 µg NaCl $g^{-1}$. The estimated regression equations are shown in Table 9. Equations are shown only if the regression was significant at the 10-20% level. Thus for Badami at 4800 µg NaCl $g^{-1}$, no regression equation was given. The rate of shoot relative yield reduction per unit increase in the shoot B concentration (slope) was increased by NaCl addition.

Table 7. Effects of added NaCl and B on the B uptake (mg pot$^{-1}$) by three pistachio cultivars.

| Added NaCl (µg/g dry soil) | Added B (µg/g dry soil) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 10 | 20 | 30 | 40 | 50 |
| | | | Badami | | | |
| 0 | 0.361±0.0104 | 0.507±0.528 | 0.376±0.0381 | 0.376±0.1065 | 1.020±0.0515 | 1.249±0.206 |
| 1600 | 0.177±0.0051 | 0.222±0.0395 | 0.294±0.0654 | 0.463±0.0266 | 0.813±0.0439 | 1.047±0.118 |
| 3200 | 0.027±0.0119 | 0.039±0.0113 | 0.108±0.0340 | 0.072±0.0075 | 0.152±0.0425 | 0.146±0.023 |
| 4800 | 0.022±0.0064 | 0.050±0.0033 | 0.058±0.0100 | 0.119±0.0384 | 0.198±0.0231 | 0.113±0.017 |
| | | | Fandoghi | | | |
| 0 | 0.166±0.0193 | 0.403±0.0784 | 1.152±0.377 | 1.267±0.2900 | 1.414±0.1788 | 2.114±0.460 |
| 1600 | 0.141±0.0161 | 0.315±0.0326 | 0.332±0.0378 | 0.402±0.0244 | 0.650±0.778 | 1.255±0.292 |
| 3200 | 0.048±0.0032 | 0.079±0.0167 | 0.103±0.0142 | 0.135±0.0419 | 0.191±0.0180 | 0.170±0.019 |
| 4800 | 0.022±0.0026 | 0.059±0.0143 | 0.034±0.0044 | 0.134±0.0094 | 0.065±0.0061 | 0.179±0.034 |
| | | | Kale-ghoochi | | | |
| 0 | 0.322±0.0133 | 0.0614±0.0346 | 0.930±0.0890 | 1.249±0.0514 | 1.365±0.0442 | 2.409±0.187 |
| 1600 | 0.289±0.0081 | 0.427 ±0.0234 | 0.473±0.0173 | 0.492±0.0216 | 0.890±0.0427 | 0.838±0.035 |
| 3200 | 0.081±0.0090 | 0.122 ±0.0251 | 0.269±0.0369 | 0.069±0.0319 | 0.228±0.0389 | 0.260±0.140 |
| 4800 | 0.032±0.0086 | 0.048 ±0.0073 | 0.058±0.0138 | 0.063±0.0075 | 0.129±0.0072 | 0.093±0.008 |

Table 8. Effects of added NaCl and B on the Cl uptake (mg pot $^{-1}$) by three pistachio cultivars.

| Added NaCl (µg/g dry soil) | Added B (µg/g dry soil) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 10 | 20 | 30 | 40 | 50 |
| | | | Badami | | | |
| 0 | 31.8 ± 3.85 | 33.7 ± 5.00 | 45.1 ± 5.08 | 28.4 ± 1.75 | 31.3 ± 3.17 | 26.7 ± 2.80 |
| 1600 | 72.8 ± 19.86 | 77.0 ± 3.33 | 54.2 ± 4.68 | 62.5 ± 20.27 | 75.4 ± 8.09 | 64.9 ± 3.44 |
| 3200 | 38.4 ± 16.93 | 52.9 ± 7.28 | 54.7 ± 8.21 | 59.5 ± 17.01 | 45.5 ±12.29 | 32.7 ± 6.71 |
| 4800 | 38.5 ± 5.16 | 48.5 ± 5.53 | 43.1 ± 4.32 | 64.1 ± 15.13 | 56.9 ± 7.38 | 64.5 ± 8.38 |
| | | | Fandoghi | | | |
| 0 | 25.7 ± 0.87 | 57.7 ± 1.27 | 55.8 ± 6.59 | 47.0 ± 5.02 | 43.6 ± 2.39 | 42.2 ± 4.48 |
| 1600 | 83.1 ± 2.99 | 116.9 ± 7.40 | 101.1 ± 10.80 | 103.4 ± 3.92 | 84.4 ± 21.82 | 87.6 ± 14.73 |
| 3200 | 73.9 ± 6.81 | 60.0 ± 12.54 | 52.6 ± 15.89 | 65.0 ± 16.68 | 74.0 ± 1.14 | 60.5 ± 8.73 |
| 4800 | 84.3 ± 1.68 | 93.9† | 49.6 ± 2.47 | 103.0 ± 10.41 | 65.6 ± 3.27 | 62.6 † |
| | | | Kale-ghoochi | | | |
| 0 | 24.2 ± 1.70 | 61.9 ± 2.33 | 65.3 ± 3.57 | 36.1 ± 5.48 | 38.1 ± 2.82 | 26.3 ± 6.25 |
| 1600 | 101.9 ± 4.49 | 108.9 ± 3.60 | 97.4 ± 4.49 | 91.0 ± 7.39 | 64.2 ± 3.48 | 81.4 ± 3.92 |
| 3200 | 89.0 ± 29.50 | 90.1 ± 24.39 | 262.3 ± 57.38 | 80.2 ± 36.66 | 134.4 ± 15.32 | 120.8† |
| 4800 | 74.4 ± 19.98 | 70.9 ± 14.81 | 60.2 ± 11.46 | 46.1 ± 2.54 | 44.9 ± 1.92 | 31.3† |

† Due to inadequate data, standard error was not calculated.

Table 9. The relationship between relative shoot dry weight (Y, %) and B concentration in the shoot (X, μg $g^{-1}$) giving 25 and 50% reduction in the growth.

| Cultivars | Added NaCl (μg/g) dry soil | Equation | r | B concentration in shoot( μg/g dry wt.) at 25% growth reduction | 50% growth reduction |
|---|---|---|---|---|---|
| Badami | 0 | Y=100-0.43 (X-8.9) | - 0.954** | 67 | 125 |
| | 1600 | Y=100-0.41 (X-41.2) | - 0.676$ | 102 | 163 |
| | 3200 | Y=100-0.27 (X-47.2) | - 0.798* | 67 | 87 |
| | 4800 | @ | @ | @ | @ |
| Fandoghi | 0 | Y=100-0.22 (X-38.1) | - 0.879** | 152 | 265 |
| | 1600 | @ | @ | @ | @ |
| | 3200 | Y=100-0.58 (X-0) | - 0.963** | 43 | 86 |
| | 3800 | Y=100-0.39 (X-80.9) | - 0.562$ | 146 | 209 |
| Kale-ghoochi | 0 | Y=100-0.19 (X-95.1) | - 0.819* | 227 | 358 |
| | 1600 | Y=100-0.80 (X-32.5) | - 0.747$ | 64 | 95 |
| | 3200 | Y=100-0.58 (X-17.9) | - 0.598$ | 61 | 104 |
| | 4800 | Y=100-0.41 (X-23.5) | - 0.736$ | 85 | 146 |

**, *, $ Significant at 1%, 5% and between 10 to 20%, respectively.

@ The regression equations were not given due to nonsignificant correlation coefficients.

According to the regression equations shown in Table 9, in nonsaline soil, a 50% reduction in shoot growth of Badami, Fandoghi and Kale-ghoochi was associated with B concentrations of 125, 265 and 358 $\mu g\ g^{-1}$, respectively. The values for Fandoghi and Kale-ghoochi at 4800 $\mu g$ NaCl $g^{-1}$ were 209 and 146 $\mu g$ B $g^{-1}$. This means that in nonsaline soil, Badami is quite more sensitive to excess B than Fandoghi and Kale-ghoochi, whereas Fandoghi is more tolerant to B than Kale-ghoochi under high salinity.

## ACKNOWLEDGEMENT

This research was supported by a grant (62-AG-327-58) from the Research Council of Shiraz University.

## LITERATURE CITED

1. Bernal, C.T., F.T. Bingham and J. Oertli. 1974. Salt tolerance of Mexican wheat. 11. Relation of variable sodium chloride and length of growing season. Proc. Soil Sci. Soc. Amer. 38:777-780.
2. Chapman, H.D and P.F. Pratt. 1961. Method of Analysis for Soil, Plants and Waters. Univ. Calif. Div. Agric. Sci.
3. Chauhan, R.P.S., C.P.S. Chauhan and S.K. Chauhan. 1984. Effect of boronated saline irrigation water on linseed. J. Agric. Sci. Comb. 102:237-240.
4. Dible, W.T., E. Troug and K.C. Berger. 1954. Boron determination in soils and plants. Anal. Chem. 26:418-421.
5. Läuchi, A. and J. Wieneke. 1979. Studies on growth and distribution of $Na^+$, $K^+$ and $Cl^-$ in soybean cultivars differing in salt tolerance. Z. Pflanzenernahar Bodenkd. 142:3-13.
6. Lessani, H. and H. Marschner. 1978. Relation between salt

tolerance and long distance transport of sodium and chloride in various crop species. Austral. J. Plant Physiol. 5:27-37.

7. Maftoun, M., A. Bassiri, A.M. Sameni and J. Yasrebi. 1982. Growth and chemical composition of soybeans as affected by trifluralin and soil salinity. Weed Res. 22:89-94.
8. Oertli, J.J. 1960. The distribution of normal toxic amounts of boron in leaves of rough lemon. Agron. J. 52:530-532.
9. Parsa, A.A. and N. Karimian. 1975. Effect of sodium chloride on seedling growth of two major varieties of Iranian pistachio (*Pistacia vera* L.). J. Hortic. Sci. 50:41-46.
10. Picchicni, G.A. and S. Miyamoto. 1990. Salt effects on growth and ion uptake of pistachio rootstock seedlings. J. Amer. Soc. Hortic. Sci. 115:647-653.
11. Sepaskhah, A.R. and M. Maftoun. 1988. Relative salt tolerance of pistachio cultivars. J. Hortic. Sci. 63:157-162.
12. Sepaskhah, A.R., M. Maftoun and J. Yasrebi. 1988. Seedling growth and chemical composition of three pistachio cultivars as affected by soil applied boron. J. Hortic. Sci. 63:743-749.
13. Sepaskhah, A.R., M. Maftoun and N. Karimian. 1985. Growth and chemical composition of pistachio as affected by salinity and applied iron. J. Hortic. Sci. 63:115-121.
14. Sepaskhah, A.R. and M. Maftoun. 1981. Growth and chemical composition of pistachio cultivars as influenced by irrigation regimes and salinity levels of irrigation water. 1. Growth. J. Hortic. Sci. 56:277-284.