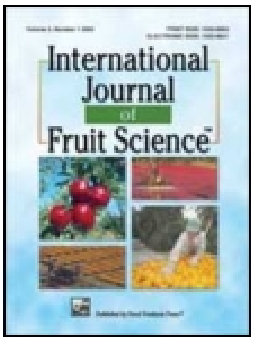

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International Journal of Fruit Science

ISSN: 1553-8362 (Print) 1553-8621 (Online) Journal homepage: www.tandfonline.com/journals/wsfr20

Determination of Salt Tolerance of ‘Camarosa’ and ‘Chandler’ Strawberries Grown in Perlite and Perlite

Zeolite Media

Ece Turhan & Atilla Eris

Determination of Salt Tolerance of 'Camarosa' and 'Chandler' Strawberries Grown in Perlite and Perlite:Zeolite Media

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ABSTRACT. The effects of salt (NaCl) applications of various concentrations (0, 500, 1000 and 2000 mg/L) for 6 months on 'Camarosa' and 'Chandler' strawberry varieties grown in perlite and perlite:zeolite (1:1) media were investigated. In order to determine the salt resistance of varieties, the tolerance index (T.I.) and tolerance ratio (T.R.) were calculated on the basis of total chlorophyll content, and leaf and root dry weight. Also, the ability of keep in balance for potassium:sodium (K:Na) ratio in the aerial part and roots of plants were considered. It was determined that the highest T.I. and T.R. values calculated on the basis of leaf and root dry weight in cv. Camarosa in both media. Concerning the evaluations calculated on the basis of total chlorophyll, the results indicated that 'Chandler' is more resistant in perlite medium, 'Camarosa' is more resistant in perlite:zeolite (1:1) medium. K:Na ratio decreased with increasing salinity in both varieties. However, it was determined that K:Na ratio is higher in cv. Chandler, i.e., 0.83 than in cv. Camarosa (0.61). As

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This study is part of the PhD thesis project supported by Uludag University Research Foundation as project no. 2000/24.

The authors thank the Uludag University Research Foundation for supporting this study (Project No: 2000/24) financially.

International Journal of Fruit Science, Vol. 7(1) 2007
Available online at http://ijfs.haworthpress.com

doi:10.1300/J492v07n01_08

a conclusion, it was determined that 'Camarosa' was more resistant to salt than 'Chandler'. In addition, regarding the salt resistant performance of plants, perlite:zeolite (1:1) medium had more effective results than perlite. doi:10.1300/J492v07n01_08 *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-HAWORTH. E-mail address: <docdelivery@haworthpress.com> Website: <http://www.HaworthPress.com>*

KEYWORDS. Strawberry, salt tolerance, perlite, zeolite

INTRODUCTION

Salinity affect plant growth, development, metabolism and it induces some changes in their morphology and anatomy (Levitt, 1980). Besides death of plant, salt stress causes quality loss, necrosis and prevents growth and yield depends on the tolerance situation (Hasegawa et al. 1986). However, the severity of salt damage has been found to be dependent on the species and varieties (Quamme and Stushnoff, 1983; Salisbury and Ross, 1992; Schwarz, 1995). A relatively wide range of variation to this sensitivity is founding bean (Pessarakli and Zhou, 1990), melon (Mendlinger and Pasternak, 1992; Franco et al., 1997; Sivritepe et al., 2003), grapevine (Sivritepe and Eris, 1999), mulberry (Agastian et al., 2000), tomato (Alian et al., 2000). Although Levitt (1980) reported that listing of salinity sensitivity based on species in detail, no listing of salinity sensitivity based on variety is available (Schwarz, 1995). Consequently, varietals differences in sensitivity to salinity are much more pronounced than in usually considered.

Although strawberry has been described by various authors as sensitive to salinity (Levitt, 1980; Schwarz, 1995), the differences between varieties also were determined in strawberry as in many other crops. For example, Dobren'Kova and Goncharova (1986) have explained that reducing of leaf area, root growth and fruit size was much less in resistant strawberry variety (Festivalnaya) than sensitive strawberry variety (Zarya). Badawi et al. (1992) showed that, 'Tufts' strawberry varieties showed higher salinity tolerance with more number of shoots and percentage survival than 'Pajaro' and 'Tioga' varieties as NaCl concentration increased. Moreover, Martinez-Barroso and Alvarez (1997) reported that when considering the incidence and evolution of leaf scorch, 'Toro' strawberry cultivar is more tolerant to salinity than 'Douglas'.

On the other hand, it is difficult to ascribe all of these phenomena to a particular effect, especially since different researchers report contradictory results. This may be partly explained by the fact that these types of experiments are conducted under various ionic compositions and differing root growth media (water, gravel, sand, soil, etc.) (Schwarz, 1995). Therefore, the objective of this work is to determine of salt tolerance in 'Camarosa' and 'Chandler' strawberry varieties grown in perlite and perlite:zeolite media and differences between the varieties.

MATERIALS AND METHODS

Seedlings of the 'Camarosa' and 'Chandler' strawberry varieties were grown in perlite and perlite:zeolite [1:1] media, for 6 months, and were watered with nutrient solution containing 0, 500, 1000 and 2000 mg/L NaCl. Awang et al. (1993) used and Anagnostou and Vasilakakis (1995) recommend that modified Hoagland solution [2/3 strength] be used as a nutrient solution for strawberry plants. The composition of the nutrient solution was as follows: in g/1000 L; 76.64 monoammonium phosphate [MAP], 404.00 potassium nitrate [KNO_3], 786.47 calcium nitrate [$Ca(NO_3)_2.4H_2O$], 328.00 magnesium sulphate [$MgSO_4.7H_2O$], 23.30 iron chelate [Fe-EDTA], 1.90 boric acid [H_3BO_3], 0.22 zinc sulphate [$ZnSO_4.7H_2O$], 0.019 ammonium molybdate [$(NH_4)_6Mo_7$], 1.54 manganese sulphate [$MnSO_4.H_2O$], 0.08 cupper sulphate [$CuSO_4.5H_2O$]. The pH of the input solution was maintained between 6.0 to 6.5 with concentrated phosphoric acid [H_3PO_4].

The average minimum and maximum temperatures and the relative humidity during the trial period in the greenhouse were 10.4°C-25.5°C and 67.0-94.5%, respectively.

Addition of the above-mentioned NaCl amounts was made to the nutrient solution 20 days after transplanting, when the plants had developed four-five true leaves. Plants were irrigated with their respective solution four-six times per day using a drip irrigation system. It was attempted to keep the quantity of drainage water at 30% of the amount of nutrient solution applied (Lieten, 1995). The salt level was gradually increased over one week to avoid osmotic shock (Wright and Hughes, 1993).

The experiment was set up using a Randomized Block Design and replicated three times. There was 1 plant in each pot [14 cm diameter], with 10 pots in each replicate.

Plants were separated into aerial and root parts and were dried at 70°C for 48 h. After that, leaf and root dry weights were determined. Total chlorophyll was determined to Arnon (1949) and calculated to Lichtenhaler and Welburn (1983) (Data not shown). Na and K content of samples digested in concentrated nitric acid [HNO_3] and perchloric acid [$HClO_4$] [4:1] were determined by flame photometry [Eppendorf Elex 6361]. After that K:Na ratios in the roots and aerial part of the plants were calculated.

In order to determine the salt tolerance in varieties and differences between the varieties, the following parameters were used:

Tolerance Index (TI): It was used to compare varieties on the basis of reactions to salt treatment, eliminating growth differences according to variety. TI was calculated on the basis of total chlorophyll content and leaf, and root dry weight, as fallows, according to LaRosa et al. (1989):

$$\text{T.I.} = 100 + \sum^{n} [x\ (Tx/To)\ 100]$$

Where,

n = number of treatment
x = 0.0, 0.5, 1.0, 2.0 g/L NaCl,
Tx = dry weight or total chlorophyll content gain on x g/L NaCl,
To = dry weight or total chlorophyll content gain on 0 g/L NaCl,

Tolerance Ratio (T.R.): Tolerance ratio was used to summarize to compare strawberry varieties on the basis of reactions to different NaCl concentrations (Chandler et al., 1986). TR was also calculated on the basis of total chlorophyll content and leaf, stem and root dry weight.

$$TR = T_x / T_0$$

Tx = dry weight or total chlorophyll content gain on x g/L NaCl,
To = dry weight or total chlorophyll content gain on 0 g/L NaCl,

The ability of keep in balance for K:Na ratios in the roots and aerial part of the plants were also considered as the third parameter to compare strawberry varieties.

Statistical analyses were carried out by analysis of variance (ANOVA) and least significant differences (LSD) at P = 0.05 are presented.

RESULTS

Tolerance Index

The findings related to tolerance indexes, calculated on the basis of leaf, root dry weight and total chlorophyll content are shown in Table 1.

At the end of the 6 months treatments of NaCl, when tolerance indexes compare on the basis of leaf dry weight, both in perlite and perlite:zeolite (1:1) media the highest TIs always obtained from cv. Camarosa. But differences between the varieties were significant only in perlite: zeolite (1:1) medium (Camarosa = 352.17, Chandler = 223.92). When the TI calculated on the basis of root dry weight, it was determined that differences between the cultivars were significant statistically in perlite medium. TIs were determined in cv. Chandler, i.e., 223.07 is more lower than in cv. Camarosa, i.e., 293.45. However, TI calculated the basis of the total chlorophyll, only in perlite medium. TI were determined in cv. Chandler, i.e., 623.79 was higher than in cv. Camarosa, i.e., 545.35.

Tolerance Ratio

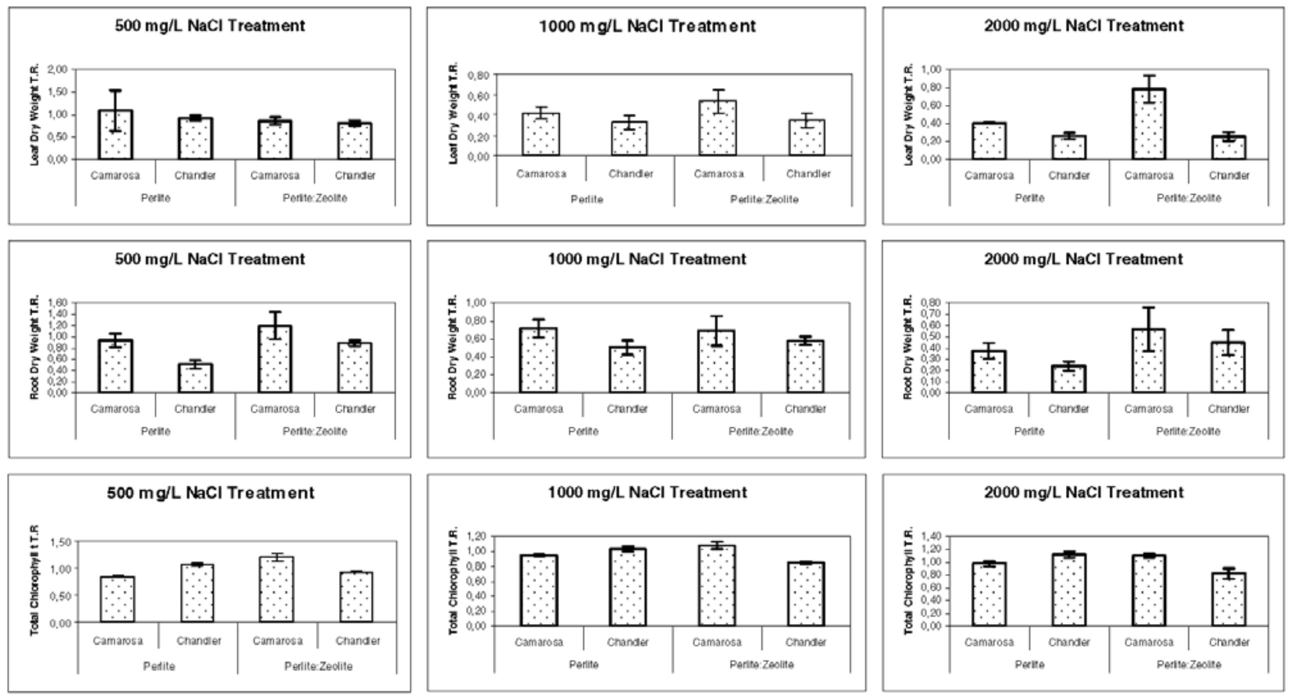
It is clear from the data that tolerance ratio generally decreased in both varieties due to increases in NaCl concentrations in both growth media (Figure 1).

TABLE 1. Tolerance indexes of strawberry varieties calculated on the basis of leaf, root dry weight and total chlorophyll in different growth media in salinity stress conditions.

Varieties	T.I. Values					
	Perlite			Perlite: Zeolite (1:1)		
	Leaf dry weight	Root dry weight	Total chlorophyll	Leaf dry weight	Root dry weight	Total chlorophyll
Camarosa	277.49 ± 28.75	293.45 ± 17.09	545.35 ± 6.42	352.17 ± 32.72	342.25 ± 58,55	626.61± 21.10
Chandler	230.07 ± 15.50	223.01. ± 3,53	623.79 ± 9.10	223.92 ± 12,57	295.62 ± 24,68	554.89± 21.96

Data are means (n = 3) ± s.e.

FIGURE 1. Tolerance ratios of strawberry varieties on the basis of leaf dry weight, root dry weight and total chlorophyll. Values are means from three replications and vertical bars indicate ± s.e.



Concerning the tolerance ratios calculated on the basis of leaf dry weight, it was determined that cv. Camarosa is more resistant to salinity than cv. Chandler at 2000 mg/L NaCl treatment in perlite medium (Camarosa = 0.41, Chandler = 0.26). It was determined that tolerance ratio value calculated on the basis of leaf dry weight as 0.53 in cv. Camarosa reduced 0.34 in cv. Chandler in perlite:zeolite (1:1) medium, at 1000 mg/L NaCl application. TR were determined in cv. Camarosa, i.e., 0.78 was higher than in cv. Chandler, i.e., 0.25. at 1000 mg/L NaCl application.

According to tolerance ratios calculated on the root dry weight, it was determined that, cv. Camarosa, i.e., 0.93 was more resistant to salinity than cv. Chandler (0.51) at 500 mg/L NaCl application.

When compared the tolerance ratios calculated on the basis of total chlorophyll in perlite medium, it was determined that cv. Chandler, i.e., 1.06 was more resistant to salinity than cv. Camarosa (0.84). On the other hand, in perlite:zeolite medium (1:1), the highest tolerance ratio was observed in cv. Camarosa in all salt concentrations.

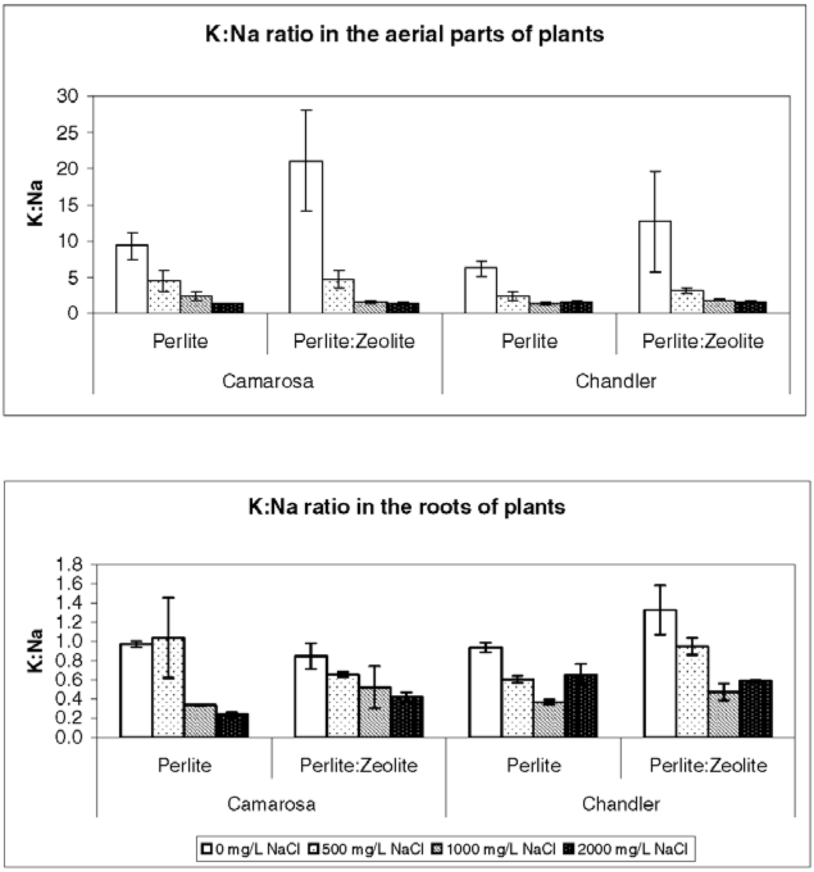
K:Na Ratio

Concerning the K:Na ratio in the aerial parts, it was determined that, there is no significant differences between the two varieties. However, as it is shown in Figure 2 clearly, K:Na ratio decreased with increasing salinity in both varieties. In root parts, it was found that differences between the varieties and salt applications were significant (Figure 2). It was determined that K:Na ratio is higher in cv. Chandler, i.e., 0.83 than in cv. Camarosa (0.61). K:Na ratio reduced in cv. Camarosa in both growth media with increasing salinity levels.

DISCUSSION AND CONCLUSION

The results of the present study showed that ‘Camarosa’ is more resistant than ‘Chandler’ to salinity according to the tolerance indexes and tolerance ratios calculated on the basis of leaf, root dry weight and total chlorophyll content of the plants. Moreover, it was determined that perlite:zeolite medium increased the tolerance ratio of the plants than perlite medium. There have been no reports demonstrating this subject in strawberry plants. However, some results about vine show partially similarity. For example, it was determined that at the end of the salt applications, salt tolerant grapevine cultivars relatively maintained their

FIGURE 2. The effects of NaCl applications on K:Na ratio in the aerial parts and root of plants. Values are means from three replications and vertical bars indicate ± s.e.



growth rates and could avoid metabolic disorders such as chlorophyll deficiency (Sivritepe and Eris, 1999).

In this study when K:Na ratio calculated, it was determined that NaCl application causes ion imbalance in the plants against to K. Similar results were obtained in tomato, olive, sunflower and wheat (Tattini, 1994; Bolarin et al. 1995; Ashraf and O'Leary 1997; El-Shintinawy, 2000; Taha et al. 2000). However, He and Cramer (1993) have reported that K:Na ratio and K-Na selectivity can not use as a reliable criteria in determining salt resistance. In the present study generally K uptake decreased depends on Na uptake and K content of plants reduced. In addition when the varieties compared according to K:Na ratio there was no differences between the varieties in the aerial part of plants. However, in the roots K:Na ratio was greater in 'Chandler' than 'Camarosa'. This may be partly explained that there is a transport problem in cv. 'Chandler'.

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doi:10.1300/J492v07n01_08