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'Hass' Avocado Response to Salinity as Influenced by Clonal Rootstocks

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Abstract. **The influence of salinity (2-4 dS/m) and clonal rootstock on 'Hass' growth was investigated using sand medium and irrigation water with controlled salinity. The clonal rootstocks were Parida, Toro Canyon, Thomas, Duke 7, G755B, and Barr Duke. Six plants per rootstock were planted at randomly selected locations in each of three sand tanks. After an establishment period of four months, under nonsaline, fertile conditions, each tank was irrigated with a water of specific salinity. Sufficient water was applied daily, with low-angle spray emitters, so that the salinity of the applied and drainage waters were equal. The plants were harvested after nine months of growth under saline conditions.**

Measurements at harvest included plant height, fresh weight, appearance, trunk diameter; and the sodium (Na^+) and chloride (Cl^-) content in the roots, stems, and leaves. Plant appearance was scored on a scale from 1 to 5 where 1 represented vigorous growth and 5 a dead plant. Average plant height (m) for the 2, 3, and 4 dS/m salinity treatments were 0.63 (a), 0.54 (b), and 0.51 (b); the corresponding average fresh weight (kg) were 2.9 (a), 1.6 (b), and 0.8 (b); and average plant appearance were 1.4 (b), 1.9 (b) and 3.0 (a), respectively. The letters denote mean separation at $P<0.01$ using LSD. Salinity did not affect the average Na^+ or Cl^- content of the roots, but both increased with salinity in the stems, mature leaves, and new growth (stems and leaves).

Rootstock affected plant appearance and the uptake and translocation of Cl^- and Na^+. Toro Canyon was the most vigorous rootstock at 1.6 (b) and Barr Duke the least at 2.6 (a). Stem Cl" content of Parida, Toro Canyon, and Duke 7 were significantly lower ($P\leq0.01$) than for Thomas, G755B, and Barr Duke. The Na^+ content of new growth for Toro Canyon was lower ($P\leq0.05$) than for the other rootstocks. There was a significant interaction ($P\leq0.01$) between rootstock and salinity for Cl^- content in the stem tissue and Na^+ content of the leaf tissue. For both parameters the content of either the stem or leaf tissue did not significantly increase with increasing salinity in the Parida, Toro Canyon, or Duke 7 rootstocks. In the remaining 3 rootstocks, Thomas, G755B, and Barr Duke, both Cl^- and Na^+ increased with increasing salinity.

Clonal rootstocks exhibit different responses to salinity. Further research and/or field experience will be required to determine if the observed salinity-rootstock interactions will affect tree productivity.

Rootstocks influence the salt tolerance of fruit trees and vine crops because of differences in absorption and transport of Cl^- and Na+ (Maas, 1990). Several studies of rootstock and salinity effects on growth of 'Hass' avocado were conducted at Brokaw Nursery in Saticoy, CA. The objectives were to characterize the salt tolerance of 'Hass' on *Phytophthora*-tolerant clonal rootstocks and to determine the effects of rootstock on Na^+ and Cl^- partitioning within the plant. Prior investigators (Ben-Ya'Acov, 1970; Downton, 1978; Gustafson *et al.,* 1970; Kadman, 1963 and 1964; Oster *et al.* 1985) have reported that the mechanism of salinity tolerance appears to include reduced transport of Cl^- and exclusion of Na^+ by the rootstock. This report summarizes the results of an experiment conducted in 1988 to 1989 which included Toro Canyon, Duke 7, Thomas, Parida, G755B and Barr Duke clonal rootstocks.

Materials and Methods

The experiment was conducted in three sand tanks using irrigation waters with salinities of 2.2, 3.2 and 4.2 dS/m (Table 1). Six plants per clonal rootstock were planted at random locations in each sand tank. After an establishment period of four months, under nonsaline, fertile conditions, each tank was irrigated with one of the saline waters. Sufficient water was applied daily, with low angle spray emitters, so the salinities of the applied and drainage waters were equal. The plants were harvested after nine months of growth under saline conditions. Measurements at harvest included plant height, fresh weight, plant appearance, trunk diameter; and the Na^+ and Cl^- content in the roots, stems, new growth (including immature leaves and shoot terminals), and mature leaves. Plant appearance was scored on a scale from 1 to 5, where 1 represented vigorous growth and 5 a dead plant. The data obtained at harvest are reported here.

Results and Discussion

<u>Salinity.</u> Tree height, trunk diameter and fresh weight decreased with increasing salinity (Table 2). Plant appearance was also affected: the appearance score increased from 1.4 (healthy to vigorous growth) at a salinity of 2 dS/m to 3.0 (poor growth), at a salinity of 4 dS/m. Salinity did not affect the average Na^+ or Cl^- content of the roots, but both increased with salinity in stems, mature leaves, and new growth (Figs. 1 and 2). Note that Cl^- was low in new growth and high in leaves, whereas, the reverse occurred for Na^+.

<u>Rootstocks.</u> Differences among rootstocks were evident for plant appearance and Cl^- and Na^+ content of plant tissue. Toro Canyon and Duke 7 had the best appearance and Barr Duke the least (Table 3). However, the plant heights for Barr Duke and Toro Canyon were about equal. Parida and G755B tended to have poor appearance and the shortest plant height. Rootstock effects on trunk girth and harvest fresh weight were not

significant, and neither were salinity/rootstock interactions for appearance, height, trunk girth or harvest fresh weight.

Rootstocks influenced partitioning of Cl^- in roots, stems and leaves, but not in new growth where Cl^- contents were relatively low for all rootstocks (Fig. 3). Parida had the lowest Cl^- levels in the roots, the third lowest level in the stems and the second lowest in the leaves. G755B had the highest Cl^- levels in the roots, the third highest level in the stems and the highest level in the leaves. However, the relationship among Cl^- contents in the roots, stems and leaves are mostly inconsistent for the other rootstocks. For example, the Cl^- content in the stems and leaves of Thomas and Barr Duke are the second and third highest as compared to being the second and third lowest in the roots. Similar inconsistencies also occurred among Na+ contents (Fig. 4) in roots, stems, new growth and leaves.

Comparisons among Cl^- and appearance are interesting. Thomas, G755B and Barr Duke had the highest Cl^- content in the stems and leaves (Fig. 3) and were among those with the poorest appearance (Table 3). Toro Canyon and Duke 7, the rootstocks with the best appearance, had the lowest Cl^- contents in the stems, and the lowest and third lowest Cl^- content in the leaves. Parida is the exception. Although Cl^- contents in the stems and leaves were low, it had the second poorest appearance: the possible cause may be its high Na^+ content in new growth, the highest of the rootstocks studied.

The differences among root-stocks for sodium content in new growth were consistent with plant characteristics. The rootstocks with the best appearance, height and fresh weight (Table 3), Toro Canyon and Duke 7, had the lowest Na^+ contents (Fig. 4). The other four rootstocks had significantly higher Na^+ contents in new growth and leaves.

Plant appearance was negatively correlated with Na^+ content of new growth and Cl^- content of stems with correlation coefficients of -0.52 and -0.43, respectively. The coefficient of determination, R^2 , was 0.48. We believe this suggests more than a simple additive effect. Time is also a factor. Sodium injury of new growth can occur before Cl^- levels in leaves become injurious. These Na^+ results indicate plant sampling to assess salinity damage in avocado should include samples of new growth in addition to mature leaves.

When salinity injury occurs during early growth stages, poor plant appearance and growth is a logical consequence. Similar salinity effects have been reported by Maas and Grieve (1990) for other plant systems. They report that salinity stress during spike apex development of wheat had the largest affect on yield.

Conclusions

'Hass’ growth on Toro Canyon and Duke 7 clonal rootstocks exhibited better tolerance to salinity than on Thomas, Parida, G755B and Barr Duke clonal rootstocks. Chloride and Na^+ content of stems, new growth, and mature leaves increased with increasing salinity and were considerably higher than Cl^- levels in new growth and Na+ levels in mature leaves. Rootstocks also affected the partitioning of these ions in plant tissue. Toro Canyon and Duke 7 had the lowest Cl^- levels in mature leaves and the lowest Na+ levels in new growth. Plant appearance among all rootstocks was negatively correlated with these two parameters. Measurement of Na^+ in new growth may be a good indicator of impending salinity stress. Genetic selection of rootstocks may result in improved salt tolerance of avocados, but data from mature trees are needed to confirm this hypothesis.

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Table 1. Irrigation water composition (meq/L).

	Irrigation water salinity, dS/m		
EC	2.2	3.2	4.2
Ca	9.5	13.6	17.5
Mg	3.1	4.1	5.6
Na	5.4	9.4	13.9
HCO_3	0.7	0.7	1.0
Cl	8.7	16.5	23.4
SO_4	7.1	8.2	10.3
NO_3	1.5	1.7	2.3

Table 2. Salinity effects on 'Hass' characteristics at harvest[z]

EC level (dS/m)	Tree Height (cm)	Appearance (1-5)	Trunk Diameter (cm)	Harvest Fresh Wt. (kg)
2	62.9 a	1.44 b	1.2 a	2.91 a
3	54.3 b	1.86 b	1.0 b	1.58 b
4	51.0 b	2.97 a	1.0 b	0.85 b
Significance	0.01	0.01	0.01	0.01

[z] Mean separation using LSD.

Table 3. Rootstock affects on growth characteristics of 'Hass' at plant harvest[z]

Rootstock	Tree Height (cm)	Appearance (1-5)	Trunk Diameter (cm)	Harvest Fresh Wt. (kg)
Parida	52.5 b	2.33 ab	1.0	1.44
Toro Canyon	58.0 ab	1.56 c	1.1	2.63
Thomas	54.9 ab	2.00 abc	1.0	1.72
Duke 7	61.5 a	1.83 be	1.1	2.23
G755B	51.5 b	2.28 ab	1.1	1.46
Barr Duke	57.9 ab	2. 56 a	1.1	1.24
Significance	0.10	0.05	N.S.	N.S.
EC x rootstock Significance	N.S.	N. S.	N.S.	N.S.

[z] Mean separation using LSD.

Figure 1. Salinity treatment effects on average chloride content of roots, stems, new growth and leaves based on irrigation water salinity. Mean separation calculated using LSD: roots (NS); stems (P≤0.01, LSD = 0.07); new growth (P≤0.05, LSD =0.04); and leaves (P≤0.01, LSD =0.27).

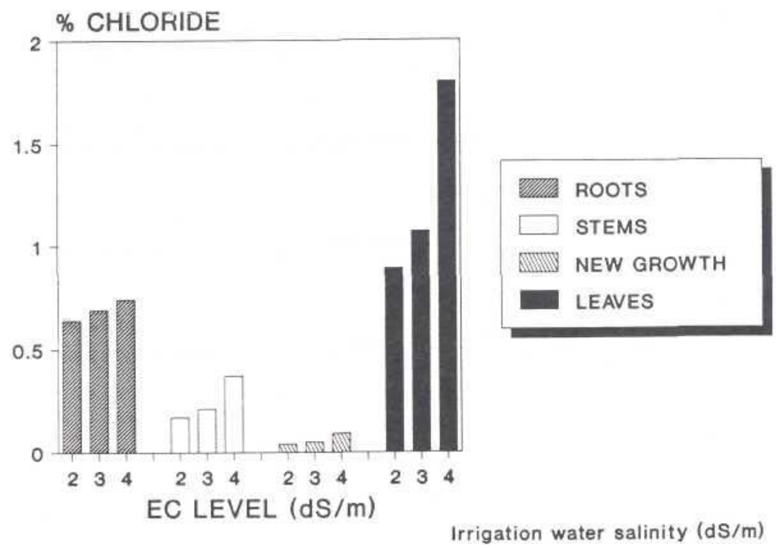

Figure 2. Salinity treatment effects on sodium content of roots, stems, new growth and leaves based on irrigation water salinity. Mean separation calculated using LSD: roots (NS); stems (P≤0.01, LSD =0.05); new growth (P≤0.01, LSD =0.26); and leaves (P≤ 0.01, LSD = 0.04).

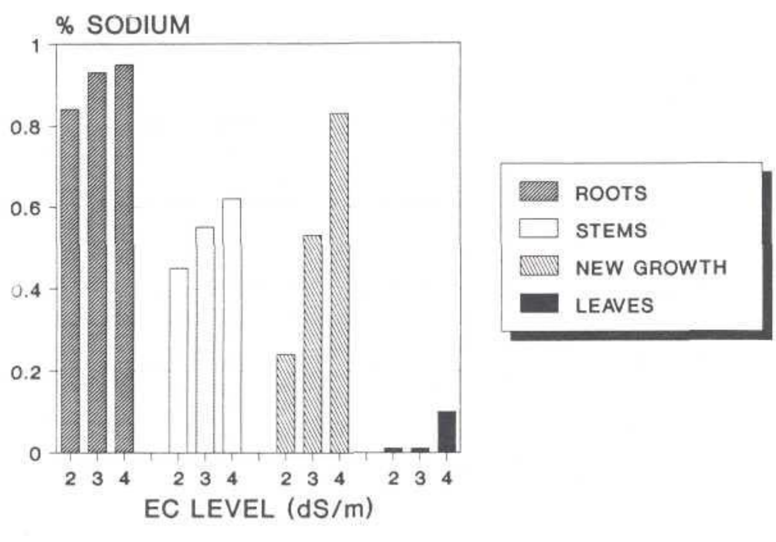

Figure 3. Rootstock effects on plant partitioning of chloride. Mean separation calculated using LSD: roots (P≤0.01, LSD = 0.20); stems (P≤0.01, LSD = 0.09); new growth (NS); and leaves (P≤0.01, LSD = 0.41).

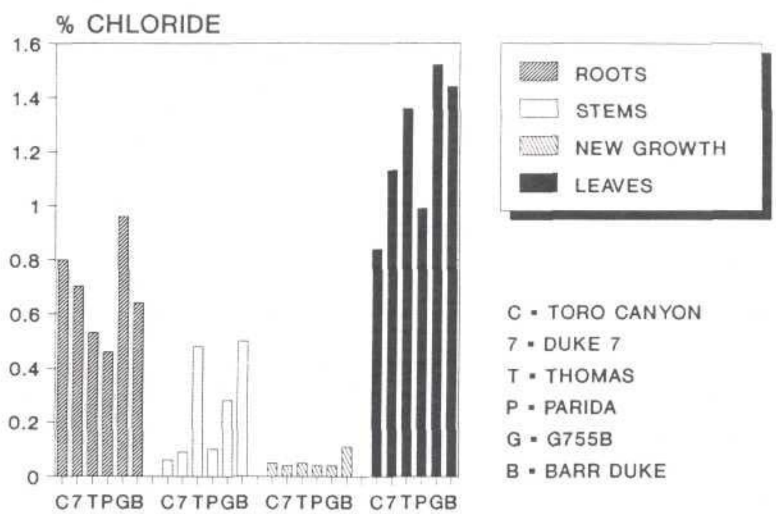

Figure 4. Rootstock effects on plant partitioning of sodium. Mean separation calculated using LSD: roots (P≤0.01, LSD=0.22); stems (P≤0.01, LSD = 0.07); new growth (P≤0.05, LSD =0.28); and leaves (P≤0.01, LSD = 0.05).