GROWTH RESPONSE OF AVOCADO ROOTSTOCKS (*PERSEA AMERICANA* MILL.) TO CHLORIDE: ROLE OF ENDOGENOUS ABA AND IAA
PRELIMINARY RESULTS

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ABSTRACT

'Hass' on West Indian VC 239 and Mexican Duke 7 rootstocks were irrigated with an iso-osmotic nutrient solution containing Cl at 2, 4, 8 or 16 meq·L^{-1} attained by using NaCl, $CaCl_2$, Na_2SO_4 and $MgSO_4$. Na, Ca, Mg and SO_4 concentrations (mmol·L^{-1}) ranged from 6.1 to 5.2, 2.6 to 7.2, 6.0 to 0.5 and 11.5 to 0.5, respectively, in the low to high Cl treatments. After 14 months, total dry mass of 'Hass' on VC 239 was positively correlated with the Cl concentration of the treatment solutions, whereas total dry mass of 'Hass' on Duke 7 was negatively correlated. Tree total dry mass was greater for 'Hass' on Duke 7 than on VC 239 for all treatments. At the low Cl (high Na) treatment, 'Hass' on VC 239 accumulated Na; Duke 7 excluded Na. Leaves of 'Hass' on both rootstocks accumulated Cl, Ca and K, but only 'Hass' on VC 239 had reduced leaf indoleacetic acid (IAA) concentration. Leaf K concentration was positively correlated with leaf abscisic acid (ABA) concentration in both combinations. Leaf K/Na was positively correlated with leaf ABA/IAA ratio for both combinations. Results demonstrated: *(i)* growth of 'Hass' was more sensitive to Cl on Duke 7 than VC239, but Duke 7 was superior to VC 239 in preventing Na accumulation and in maintaining growth; *(ii)* during Cl-stress of avocado, leaf K paralleled leaf ABA independently of rootstock; and *(iii)* leaf ABA/IAA ratio is physiologically linked to leaf K/Na ratio in both combinations.

INTRODUCTION

Increased biosynthesis and accumulation of abscisic acid (ABA) are well-documented plant responses to abiotic stresses, including salinity. Exogenous application of ABA to annual crops increases K uptake by roots (Roberts and Snowman, 2000) and increases the K/Na ratio of plants grown under salt stress (Bohra et al., 1995). The role of endogenous ABA, or other plant growth regulators, in chloride tolerance/sensitivity of 'Hass' avocado is unknown. Two avocado rootstocks, Mexican race Duke 7, the predominant rootstock in commercial avocado orchards in California, and West Indian VC 239, a putative salt-tolerant rootstock selected in Israel, each grafted with 'Hass', were used in the research. Trees, 1.5 years from grafting, were irrigated with iso-osmotic half-strength Hoagland's nutrient solution (Hoagland and Arnon, 1938), which was modified to contain Cl at 2, 4, 8, or 16 meq·L^{-1} by using various concentrations of NaCl, $CaCl_2$, Na_2SO_4, or $MgSO_4$. The effect of chloride treatments on plant growth and mortality, leaf nutrient status and on endogenous concentrations of PGRs was quantified for 14 months. Herein, we report the results obtained at the end of 14 months of treatment.

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MATERIALS AND METHODS

Plant Material

'Hass' avocado scions (*Persea americana* Mill.) grafted on West Indian rootstock VC 239 or on Mexican race Duke 7 rootstock were used in the research.

Chloride Treatments.

The avocado trees were planted in 19 L of sand in a plastic nursery pot 1.5 years after grafting. The trees were irrigated with half-strength Hoagland's nutrient solution (Hoagland and Arnon, 1938) adjusted with sodium and calcium chloride and sodium and magnesium sulfate to obtain chloride concentrations of 2, 4, 8 and 16 $meq{\cdot}L^{-1}$. This resulted in a range of Na, Ca, Mg and SO_4 concentrations ($mmol{\cdot}L^{-1}$) in the low Cl to high Cl treatments from 6.1 to 5.2 for Na, 2.6 to 7.2 for Ca, 6.0 to 0.5 for Mg and 11.5 to 0.5 for SO_4. EC for all treatments was 3.0 $dS{\cdot}m^{-1}$.

Leaf Nutrient Status

Leaf nutrient concentrations reported herein were determined by the Dept. of Environmental Sciences, Univ. of Calif., Riverside.

Leaf Endogenous PGR Concentrations

Endogenous concentrations of abscisic acid (ABA), indoleacetic acid (IAA), and isopentenyladenosine (IPA) were isolated, purified and quantified using radioimmunoassay (Cutting et al., 1986). Only results for abscisic acid (ABA) and indoleacetic acid (IAA) are reported here.

RESULTS

Plant Growth and Survival

Total biomass (dry mass, DM) and biomass of leaves, stems and roots of 'Hass' on Duke 7 decreased as the Cl concentration of the treatment solutions increased (Table 1). In contrast, total biomass and leaf, stem and root biomass of 'Hass' on VC 239 increased as the Cl concentration of the treatment solutions increased. Plant mortality was not related to the Cl concentration of the treatment solutions (data not shown).

Leaf Nutrient Status

'Hass' on both rootstocks had significantly higher leaf concentrations of Cl, Ca and K when grown for 14 months at 16 meq $Cl{\cdot}L^{-1}$ than at 2 meq $Cl{\cdot}L^{-1}$ (Table 2). The treatment solution containing 16 meq $Cl{\cdot}L^{-1}$ contained, respectively, 8-fold and 2.8-fold more Cl and Ca than the 2 meq $Cl{\cdot}L^{-1}$ treatment solution, but both solutions had the same concentration of K, that of half-strength Hoagland's nutrient solution.

'Hass' on Duke 7 maintained leaf Na concentrations of 20 ppm for all Cl treatments. In contrast, leaves of 'Hass' on VC 239 grown at 2 meq $Cl \cdot L^{-1}$ accumulated 200-fold more Na, due most likely to the low Ca concentration of this treatment (Table 2). Leaves of 'Hass' on both rootstocks had higher concentrations of Mg and SO_4 when grown at 2 meq $Cl \cdot L^{-1}$ ($P<0.001$), but the concentrations were in the preferred range. The 2 meq $Cl \cdot L^{-1}$ treatment contained, respectively, 12-fold and 23-fold more Mg and SO_4 than the 16 meq $Cl \cdot L^{-1}$ treatment, but only 1.2-fold more Na.

Leaf Endogenous PGR Concentrations

Endogenous ABA or IAA concentrations of 'Hass' avocado leaves were not affected by rootstocks or Cl treatment. For 'Hass' on both rootstocks, leaf ABA concentrations were positively correlated with leaf K concentrations, but not with leaf Cl or Ca concentrations (Table 3). Leaf IAA concentrations were negatively correlated with leaf Cl concentrations, but not with leaf Ca or K concentrations for 'Hass' on VC 239. No leaf nutrient concentration was related to leaf IAA concentration for 'Hass' on Duke 7. Leaf ABA/IAA (ng/g DM:ng/g DM) was positively correlated with leaf K/Na (g/100 g DM:g/100 g DM) for 'Hass' on both rootstocks.

CONCLUSIONS

- Growth of 'Hass' on Duke 7, but not on VC 239, was reduced by Cl accumulation, but total biomass of 'Hass' on Duke 7 grown at 16 meq $Cl \cdot L^{-1}$ was 3-fold greater than on VC 239.
- Duke 7 excluded or sequestered Na; VC 239 did not, and the growth of 'Hass' on VC 239 was reduced by Na accumulation.
- K accumulation in leaves of 'Hass' on both rootstocks was positively correlated with leaf ABA concentration ($P \leq 0.02$, Duke 7; $P \leq 0.10$, VC 239), but independent of growth, leaf Cl concentrations, and Cl and K concentrations in the treatment solutions.
- Leaf ABA/IAA was a good predictor of leaf K/Na and Na selectivity of the rootstock.

Literature Cited

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Table 1. Effect of Cl treatments on leaf, stem, root and total biomass after 14 months.

		Treatments (meq Cl·L^{-1})		
Organ	Rootstock	2	16	%[z]
		g DM ± SE		
Leaves	Duke 7	366 ± 112	190 ± 5	52
	VC 239	10 ± 5	66 ± 19	660
Roots	Duke 7	503 ± 115	350 ± 2	70
	VC 239	67 ± 9	102 ± 35	152
Stems	Duke 7	469 ± 115	1245 ± 43	52
	VC 239	21 ± 3	87 ± 17	414
Total	Duke 7	1338	785	59
	VC 239	98	255	260

[z]Biomass (DM) of plants after 14 months at 16 meq Cl·L^{-1} divided by the biomass (DM) of plants grown for 14 months at 2 meq Cl·L^{-1}.

Table 2. Effect of Cl treatments on leaf nutrient status after 14 months.

		Treatments (meq Cl·L^{-1})	
Rootstock	Nutrient	2	16
		ppm	
Duke 7	Cl	870 ± 170	5050 ± 640
	Na	20 ± 10	20 ± 10
	Ca	6400 ± 400	11800 ± 2200
	K	6500 ± 400	8800 ± 100
VC 239	Cl	990 ± 170	4960 ± 640
	Na	4400 ± 1620	190 ± 60
	Ca	4300 ± 800	12100 ± 1000
	K	10200 ± 2900	9300 ± 800

Table 3. Effect of Cl treatments on the relationship between leaf ABA and K concentration, leaf IAA and Cl concentration, and leaf ABA/IAA and K/Na.

	VC 239		Duke 7	
Variables	r	*P*-value	r	*P*-value
Leaf ABA to leaf K	0.50	0.10	0.70	0.02
Leaf IAA to leaf Cl	–0.56	0.07	–0.03	0.93
Leaf ABA/IAA to leaf K/Na	0.56	0.06	0.73	0.01