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Potassium Uptake by Avocado Roots

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Abstract. **Large variations in root growth and in root system architecture were found among different races of avocado *(Persea americana* Mill.)- Roots of the West Indian races grow deeper than the root systems of the Mexican and the Guatemalan races (Flores-Meza *et al.,* 1988). Most of the leader roots of avocado are thick, with even young ones reaching a diameter of 3 to 5 mm before secondary thickening. Lateral roots are usually thinner. The root tips are white, and gradually turn brown and become suberized. It is generally assumed that water and nutrients are absorbed mainly by the tips.**

The aim of the present research was to compare potassium uptake and respiration of roots of different branching order: leader roots, first order laterals and second order laterals. Roots of two races were compared: the West Indian, a salt-tolerant race and the Mexican, a salt-sensitive one. Emphasis was given to the uptake pattern of potassium, under saline and non-saline conditions.

Materials and Methods

Two avocado rootstocks; a salt-tolerant West Indian rootstock, Deganya 117, and a salt-sensitive Mexican one, Schmidt, were investigated. Roots were taken either from the aeroponic root chamber of the "Sarah-Racine root laboratory" from an 8-year-old tree or from aerated hydroponic cultures where young seedlings were grown in Hoagland's nutrient solution. Roots of different branching order (leader roots 3-4 mm, 1st order laterals 1.5 mm, and 2nd order laterals 0.75 mm in diameter) were used for experimentation. Excised roots (6 cm long) were immersed for 10 min in 1 mM KCI solution labelled with ^{86}Rb. They were then washed with cold (1-2C) distilled water for 1 min and immersed in a cold (1-2C) exchange solution (1 mM KCI + 10mM $CaCl_2$) for 30 min. Tissue to solution volume ratio was approximately 1:50 in the uptake solution and 1:100 in rinse and exchange solutions.

The individual roots were then cut into 0.5 or 1 cm segments and each segment was weighed. The basal segment of each root was discarded. The root diameter was measured and the surface area and volume were calculated, assuming a cylindrical shape. Radioactivity was measured by liquid scintillation and up- take was calculated per fresh weight or per surface area. Volume of the air spaces was determined by the weight difference before and after infiltration of the root segments with water under vacuum.

Results

Changes in color were distinguished along the roots. Root tips (0-1.5 cm) were white whereas all other segments (1.5-5.0 cm) were light brown.

The weight of the various root types differed considerably, with the leader roots being heaviest (Fig. 1). The volume of the air spaces also differed in the various root types. The tips of thin roots had the largest air space fraction (Fig. 2). In all three root types potassium was absorbed all along the investigated roots. The highest uptake rates were observed in the apical 1 cm, and the rates declined basipetally (Fig. 3). Uptake of K by the various segments, calculated per unit surface area, showed similar patterns along the roots (Fig. 4). The thinner, second order laterals, were more efficient than the thick ones.

Potassium uptake by avocado roots exhibited an unusual temperature response curve. Uptake was higher at both extreme ends of the measured range (5C and 39C) (Table 1).

The temperature response of respiration was "normal", with a maximum at 25C (Table 2). Respiration rates of the 1 cm apical root tips were twice as high as that of the 3rd cm segments.

Sodium chloride (50 mM NaCI) reduced the absorption rates of K by both the salt-sensitive and salt-tolerant rootstocks. Inhibition of K uptake by NaCI averaged 35% for the West Indian race (Fig. 5A) and 46% for the Mexican race (Fig. 5B).

Discussion

To the best of our knowledge, this is the first detailed analysis of the characteristics of individual roots of salt-sensitive and salt-tolerant varieties of avocado. Potassium uptake along the roots yielded a declining curve with rates decreasing with either the location of the segment or with its age. Variations in absorption along the roots of both rootstocks were similar. Potassium uptake by the roots of the Mexican rootstock was higher (== 13%) than that of roots of the West Indian race. The white root apices are those considered responsible for most of the mineral supply to avocado trees. The data presented here indicate that although potassium is absorbed by the apical segments at high rates it is also taken up by the brown root parts. Thus, because the mass of the brown roots exceeds that of the white tips by a factor of 1:50 at least, most of the K absorbed by the root system of an avocado tree is taken up by such roots.

Differences in K uptake among various root types were observed (Waisel *et al*., 1990). The thin second order laterals, absorbed more K per unit fresh weight and per unit surface area then thick roots. This suggests that a rootstock with a larger proportion of thin roots will be more beneficial to the plants, enabling a better ion uptake.

Short-term uptake rates can be calculated either on the basis of the cell's volume or its surface area. Tissue fresh weight is usually used as an approximate measure of its volume. Hence, the traditional expression of uptake rates per unit fresh weight. Whenever surface area was calculated, it was based on the root's outer dimensions. However, what really counts in the determination of uptake is the actual size of the inner surface area of the tissue, which is available for ion uptake from the free space. Some clues of the size of the inner surface area can be obtained from the volume of the tissue's air space. The fact that thin, second order lateral roots, are more efficient K absorbers might have been interpreted as the result of having a larger outer surface area per g. The results presented here disprove such an interpretation, showing that the advantage of the thin roots was preserved when K uptake was calculated either per weight or per unit surface area (Figs. 2 and 3). However, as thin roots have a larger airspace volume than other root types, this might indicate that K uptake is limited by the size of the inner surface, rather than by that of the outer one.

Since K uptake by avocado roots is a metabolically active process, the effects of temperature on this process were investigated. Results were puzzling because of the U-shaped curve of temperature response that was obtained. Potassium uptake was higher at 5C or at 39C but lower at 1 7 to 25C. This feature seems to be specific for K uptake because optimum temperatures for vegetative growth of avocado were shown to be in the 25 to 33C range (Lahav and Trochoulias 1982, Whiley *et al..* 1990). One possible explanation is that K uptake is influenced by several concomitant processes. Each of these processes has a different temperature response and therefore, the total sum of their activity yields that abnormal uptake curve. Another explanation could be that K uptake is affected by certain inhibitors which are highly active at the 17 to 24C range, but lose their activity either at low temperatures or at high ones. The "normal" temperature response of respiration, with a maximum about 25C, indicates that K uptake is limited by processes other than those of the energy metabolism.

One of the commonly identified salinity damage mechanisms is the interference of Na with K uptake through inhibition at the uptake sites (Epstein, 1972; Waisel, 1972). No difference was found in this respect, between the salt-sensitive and the salt-tolerant avocado rootstocks; in both races K uptake was similarly inhibited by NaCI. It is therefore concluded that salt-resistance of the West Indian rootstock, which was observed in the orchards, should be sought at another level.

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Literature Cited

Epstein, E. 1972. Mineral Nutrition of Plants: Principles and Perspectives. John Wiley & Sons Inc. New York.

Flores-Meza D., L. Vite-Cisneros, and M.W. Borys. 1988. Laterals distribution on the principal roots in avocado seedlings *(Persea americana* Mill). Calif. Avocado Soc. Yrbk. 72:237-242.
Lahav, E. and T. Trochoulias. 1982. The effect of temperature on growth and dry matter production of avocado plants. Austral. J. Agr. Res. 33: 549-558.
Whiley, A.W., B.W. Wolstenholme, J.B. Saranah, and P.A. Anderson. 1990. Effect of root temperatures on growth of two avocado rootstock cultivars. Acta Hort. 275:153-160.
Waisel, Y. 1972. Biology of Halophytes. Academic Press. New York. 395 pp.
Waisel, Y., M. Zilberstaine, and A. Eshel. 1990. Differences in ion uptake among avocado roots. Physiol. Plantarum 79:517.

Table 1: Effect of temperature on K uptake by apical 5 cm of West Indian avocado root segments. Means ± SD of five replications.

Temperature (C)	K uptake rate (nmol/g FW)
5	353.5 ± 29.7
11	220.0 ± 10.3
17	160.1 ± 19.8
24	212.3 ± 70.4
32	225.0 ± 20.2
39	340.0 ± 20.4

Table 2. Effects of temperature on the respiration of the apical 5 cm of West Indian race avocado root segments. Five cm long roots. Mean ± SD of six roots, replicated three times.

Temperature (C)	Root type	Respiration rate (nmol 0_2/ mg FW/h)	
		1 cm (tips)	3rd cm
5	Leader	20.3 ± 1.6	9.3 ± 1.6
	2nd order laterals	23.0 ± 5.8	7.9 ± 1.5
25	Leader	39.1 ± 1.0	17.9 ± 1.2
	1st order lateral	50.6 ± 1.1	27.0 ± 5.4
	2nd order lateral	62.7 ± 8.1	28.8 ± 8.2
39	Leader	27.4 ± 0.9	11.1 ± 1.5
	1st order laterals	46.3 ± 1.8	29.3 ± 1.1

Fig. 1. Distribution of weight along avocado roots. Leader roots (open columns;, isi order laterals (hatched columns) and 2nd order laterals (crossed columns). Means ± SD of 5 replicates.

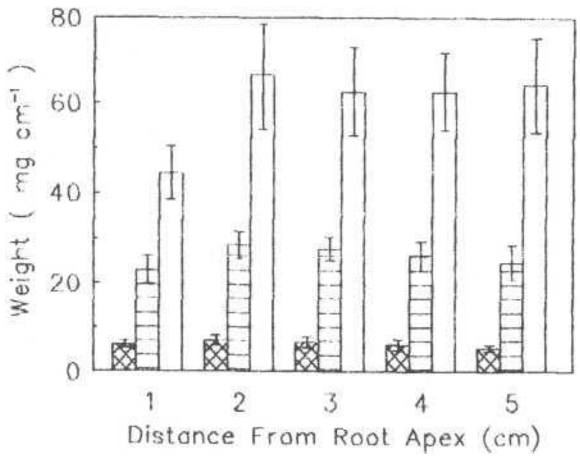

Fig. 2. Distribution of the air space volume fraction along avocado roots. Leader roots (open columns), 1st order laterals (hatched columns), 2nd order laterals (crossed columns). Means ± SD of 5 replicates.

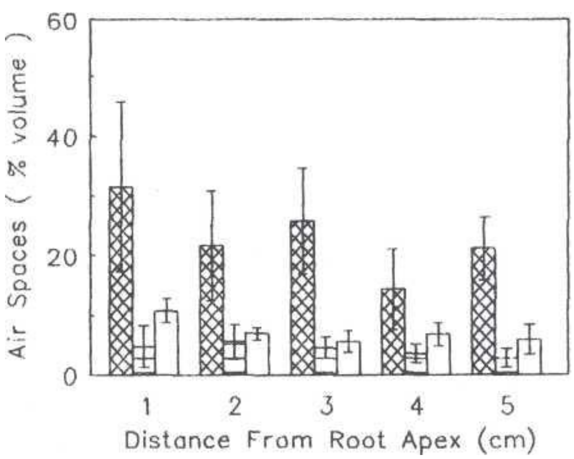

Fig. 3. Variations in potassium uptake (nmoles/g FW) along avocado roots. Leader roots (open columns), 1st order laterals (hatched columns) and 2nd order laterals (crossed columns). Means ± SD of 5 replicates.

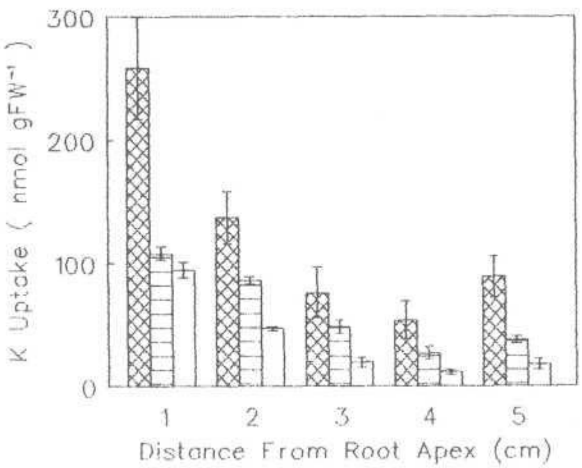

Fig. 4. Variations in potassium uptake (//moles/mm) along avocado roots. Leader roots (open columns), 1st order laterals (hatched columns) and 2nd order laterals crossed columns). Means ± SD of 5 replicates.

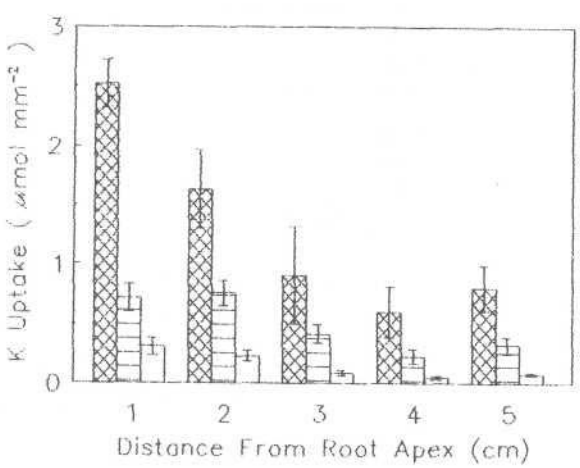

Fig. 5. Variations in potassium uptake (nmoles/g FW) along roots of avocado in the absence (crossed columns) and the presence (open columns) of 50 mM NaCl. Means ± SD of 5 replicates. A. West Indian race. B. Mexican race.