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The Uptake and Accumulation of Sodium in Avocado Seedlings[1]

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Abstract. The uptake and distribution of Na in avocado seedlings was studied. Symptoms of Na toxicity found in the leaves were always associated with high (1% and more) Na content in the injured leaves. High Na content was found in the roots of most plants without any root damage. The Mexican Northrop seedling variety was found to be most sensitive to Na. It is suggested that some barrier to Na movement exists in avocado roots. When the roots are injured, this mechanism is disturbed, thus releasing Na to move freely from the roots to the shoots.

INTRODUCTION

Sodium has been found to accumulate in various parts of avocado plants even when present in the growing media in fairly low concentrations (1, 4, 9, 11). Symptoms of Na toxicity in avocado were described as necrotic spots scattered on the leaf between the veins. These symptoms were always associated with high Na content in the leaves (1,3, 4). Some experiments have shown that the nature of Na uptake by various plants is quite complicated (2, 5, 6), and may depend on various factors, some of which affect the root system (8, 10).

In the experiment described here, the uptake and accumulation of Na by seedlings of 8 avocado varieties was examined.

MATERIALS AND METHODS

Details of the experiment have been described previously (7). In brief, 576 avocado seedlings of 8 varieties from various horticultural races, were grown in 96 large containers, (150 liters), 6 seedlings in each, and were irrigated for 28 months with saline water containing 330 ppm Na as NaCl. The total amount of Na added per container during the experiment was 114 g.

One year after the beginning of the experiment and at 6-month intervals thereafter, single plants were removed from each container and analyzed separately for Na content in the leaves, stems and roots. Soil samples were taken and analyzed for Na content. *Methods of analysis:* The plant samples were separated into leaves, stems and roots, then thoroughly rinsed with tap and distilled water, oven dried for 24 hrs at 65° C, and ground in a 40-mesh screen Wiley mill. One g samples were taken for Na determination. The material was dry-ashed in a muffle furnace for 3 hrs at 550° C, and the Na determined by an EEL flame photometer.

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RESULTS

Plant analyses: The mean Na content in leaves, stems and roots for each sampling date for all replications of each seedling population are shown in Table 1.

In the first period, Na content in the leaves of all varieties was low, except for the Mexican Northrop variety, in which the value was significantly higher (1% level) than in all other varieties. In the second period, the Na remained low for the first 3 varieties listed (all belonging to the Guatemalan race), whereas a marked increase was shown in the leaves of the other varieties, especially in the Northrop and G1 7 (Mexican) varieties. Northrop showed a significantly higher value than all the rest. In the third period a marked decrease of Na content in the leaves of the last 5 varieties was shown, whereas in the first 3 varieties there was only a small change.

The Na content in the stems showed trends more or less similar to those in the leaves: low in the first period, a marked increase in the second, and a decrease in the third period. The Northrop variety always showed significantly higher values (1% level) than the other varieties. The Na content in the roots of all varieties was several times greater than that of the leaves, except in the Northrop variety, where it was always higher in the leaves than in the roots.

Table 1.—Mean % of Na in the leaves, stems and roots of avocado seedlings according to variety and sampling date.

Sampling date/variety	Ana-heim	Benik	Nebal	Lula	Fuerte	Mexi-cola	North-rop	G1.7	Mean for dates
Leaves									
June 7, 1959	0.046	0.043	0.072	0.069	0.066	0.077	0.287	0.069	0.091
Dec. 7, 1959	0.056	0.053	0.068	0.119	0.170	0.163	0.960	0.233	0.224
June 7, 1960	0.069	0.071	0.071	0.088	0.096	0.104	0.360	0.078	0.117
mean for varieties	0.057	0.056	0.070	0.092	0.111	0.114	0.536	0.127	
Stems									
June 7, 1959	0.052	0.062	0.128	0.050	0.097	0.074	0.209	0.089	0.095
Dec. 7, 1959	0.085	0.086	0.118	0.366	0.236	0.246	0.460	0.289	0.235
June 7, 1960	0.084	0.081	0.068	0.102	0.154	0.175	0.335	0.187	0.148
mean for varieties	0.073	0.076	0.105	0.173	0.162	0.165	0.335	0.188	
Roots									
June 7, 1959	0.098	0.126	0.289	0.130	0.227	0.104	0.212	0.230	0.177
Dec. 7, 1959	0.374	0.452	0.509	0.677	0.590	0.473	0.334	0.523	0.491
June 7, 1960	0.282	0.272	0.318	0.250	0.382	0.266	0.329	0.223	0.290
mean for varieties	0.251	0.283	0.372	0.352	0.400	0.281	0.292	0.325	

The mean values of Na content were calculated for all sampling dates according to the different varieties. The Na content in the leaves of most varieties was fairly low, except for Northrop, in which it was very high. The Na values in the stems of most varieties were somewhat higher than in the leaves, except for Northrop, in which it was much lower than in its leaves; still it was several times higher than in the stems of the other varieties. The Na content in the roots of all varieties except for Northrop was much higher than in the respective leaves or stems. In Northrop the Na content in the roots was much lower than in its leaves or stems.

Plant symptoms: No symptoms of leaf injury associated with high Na content in the leaves were observed except in Northrop seedlings, in which typical necrotic spots appeared between the veins about a year after the experiment was started. In all cases where this damage was observed, it was associated with high Na content in the leaves.

This damage became more pronounced with time, and was followed by blackening and drying out of the twigs. A complete decline was noted in Most Northrop seedlings within 20-28 months. In all cases of such decline, the root systems showed severe injury, many roots were dry and almost no new roots were noted, in contrast to all the other seedlings, in which new roots were continuously formed. All seedling populations showed various degrees of leaf tip and margin burn which were associated with high Cl content in the leaves (7).

Soil analysis: The soluble Na content in the soil, calculated as meq/ 100 g soil, showed a marked progressive increase with time, from 0.17 meq/100 g before the start of the experiment to 1.04 after 12 months, 1.65 after 24 months, and 2.10 meq/100 g after 30 months, when the experiment was terminated.

DISCUSSION

Differences existed in the uptake and accumulation of Na by various avocado seedling populations. The Mexican varieties were more sensitive to Na than the Guatemalan or West Indian varieties. The Northrop variety was most sensitive to Na content in the growth medium.

Leaf symptoms of Na toxicity appeared only when the Na content in the leaves reached values of approximately 1% or higher, which is about 10-20 times greater than normally found in avocado leaves.

The distribution of Na in the various parts of the plants seems to be of a great importance. In the present experiment, high concentrations of Na were found in the roots of all plants, whereas the values in the leaves were low in most cases. A gradient of Na content was found from the roots to the stems to the leaves. Only in the plants of the Mexican variety, Northrop, where the Na content in the leaves reached 1 % and more of the dry matter, were severe symptoms of necrosis found in the leaves. The ratio of the mean values of Na content in the roots/leaves in the Northrop seedlings was about 1:2, while in most other varieties the ratio was 3-4:1.

Huffaker and Wallace (5), working with various plant species, found a similar gradient in Na content. They indicated that at low Na levels, Na appeared to be excluded at or below the shoot-root transition zone.

In the present experiment, apparent symptoms of Na toxicity in the shoots were always associated with decline of the roots in the affected plants. It seems that some type of Na barrier may exist in the avocado roots. It is suggested, however, that injury to the roots may disturb the barrier mechanism and thus lead to a quick movement of the Na from the roots into the shoots. The question arises: what is the reason for the root decline in the injured plants? Although this question was not directly investigated, it seems unlikely that the high Na content in the root *per se* was the reason for the root decline. The roots of all seedlings had high Na concentrations, but none of them except the Northrop seedlings showed any Na toxicity damage.

In an experiment (to be published later) dealing with the influence of a metabolic inhibitor on the distribution of Na^{22} in avocado seedlings, it was found that KCN greatly enhanced the movement of Na into the leaves. In work with bush bean plants, similar results were obtained (10).

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