California Avocado Society 1952 Yearbook 37: 159-166

SODIUM EFFECTS ON AVOCADO ROOTSTOCKS

A. R, C. Haas
Plant Physiologist, University of California, Citrus Experiment Station, Riverside.

SUMMARY

Avocado leaves and shoots from experimental and orchard trees are known under certain conditions to absorb considerable sodium. Seedlings of some of the avocado varieties of the Mexican and Guatemalan races (eligible as rootstocks) were grown in controlled sand cultures with nutrient solutions containing various concentrations of sodium.

The leaves of the seedlings of the different avocado varieties reacted differently to the same concentration of sodium in the nutrient solution. The root systems of certain avocado seedlings vary greatly in their retention of absorbed sodium. A large amount of leaf injury resulted when the root systems absorbed considerable sodium and permitted much to pass into the leaves. In the case of the Mexicola and Harmon avocado varieties, the increased leaf sodium was accompanied by a decrease in the percentages of calcium and magnesium m the dry matter of the leaves.

The seedlings of the Anaheim avocado variety produced excellent growth with no leaf damage whatsoever when 200 p.p.m. of sodium was used in the culture solution, very little of the absorbed sodium reaching the leaf tissues.

When sodium salts occur in the soils of avocado orchards, considerable amounts of sodium may be absorbed into the scion leaves and twigs. Frequently the resulting injury is increased or differentiated because of the effect of the ion accompanying the sodium as for example: chloride, sulfate or carbonate, and possibly by the nature of the rootstock variety. In years of scant rainfall the tree injury may be increased particularly in the case of the chloride. In certain areas especially in San Diego County, the soils may contain a relatively low concentration of calcium and magnesium which also [tends to add to the summation tree damage.

Recent investigations (1, 2, 3, 4) have shown the extent to which sodium and its often accompanying element (chloride) are absorbed by avocado leaves of experimental and orchard trees. Severely injured Itzamna avocado trees on which the leaves were severely burned and on which many of the shoots were black instead of green, were

subjected to chemical analysis and it was found that the shoots contained high concentrations of sodium. Blackened shoots ¼ to ⅜ inches in diameter contained 1.482 per cent of potassium and 1.545 per cent of sodium in the dry matter whereas the calcium was 0.615 per cent and the magnesium 0.361 per cent. Shoots of similar size but still green in color contained 0.713 per cent of potassium and 1.045 per cent of sodium in the dry matter whereas the calcium was 0.562 per cent and the magnesium 0.471 per cent.

When the blackened bark of such shoots was separated from the wood, the dry matter of such bark was found to contain 1.523 per cent of potassium and 0.927 per cent of sodium, the calcium and magnesium percentages being 0.523 and 0.247 respectively. The dry matter of the wood of such de-barked shoots contained 1.309 per cent of potassium and 0.952 per cent of sodium whereas the calcium was 0.147 per cent and the magnesium 0.129 per cent. Thus the shoots of avocado trees in the orchard may contain excessive concentrations of sodium, not only in the bark but also in the woody cylinder inside the bark and of course the leaves in such cases show severe sodium injury.

In contrast with these results, it was found (5) with Lisbon lemon trees on sour orange rootstock that, in this combination, much of the sodium does not reach the leaf tissue.

It seemed desirable to study the movement of sodium in various citrus and avocado plants most frequently used as rootstocks, in order to determine the degree to which absorbed sodium is transported to the leaves and the extent of the leaf injury that accompanies such sodium transfer. Additional studies are also underway in order to determine the movement of chlorine in various avocado rootstock plants because of the extreme sensitiveness of avocado leaves to excessive chlorine absorption.

The preliminary experiments with sodium have indicated that the leaves of certain avocado rootstock varieties are more sensitive than those of other varieties to the same concentration of sodium in the nutrient medium (sand cultures).

In these initial studies, seed of the Topa Topa, Harmon, Mexicola, and Caliente varieties were selected in order to represent the Mexican race of rootstock varieties whereas seed of the Anaheim variety were used to represent an avocado variety of the Guatemalan race. The seed coats were removed and a thin slice was cut at the apex and base of each seed prior to their being planted in the plaster sand in the propagation frame maintained at approximately 75° F.

On January 31, 1952, a young avocado seedling was planted in each three gallon-capacity crock filled with pure silica sand. Each of the designated varieties was represented by two cultures. One culture for each variety received nutrient solution containing 100 parts per million of sodium added as the nitrate whereas another culture for each variety received the same nutrient solution but containing 200 parts per million of sodium added as the nitrate. The nutrient solution employed was Hoagland's solution containing boron, manganese, zinc, iron, aluminum, and copper. Once every week these sand cultures received four liters of culture solution.

The resulting growth was observed daily until September 9, 1952, when the experiment was terminated. On June 13, 1952, the Topa Topa, Caliente and Anaheim varieties of

seedlings showed no leafburn. Leaves of the Harmon variety showed no burning at the lowest sodium but very severe leafburn at the highest sodium concentration. Mexicola seedlings showed slight leaf injury at the lowest sodium and severe leafburn at the highest sodium concentration.

Fig. 1. *Effect (June 25, 1952, on avocado seedlings planted January 31, 1952) of 100 and 200 p.p.m. respectively of sodium added as nitrate to culture solutions applied to three-gallon-capacity sand cultures. Left to right: crocks 1, 2 (Topa Topa); 3, 4, (Harmon); 5, 6 (Mexicola). Leaves of Harmon and Mexicola seedlings were severely injured at 200 p.p.m. of sodium whereas the leaves of the Mexicola seedling showed slight injury at 100 p.p.m. of sodium. Ruler in crock 3 (left to right) represents one foot.*

Figure 1 shows the leaf condition on June 25, 1952. Crocks 1, 3, and 5 (left to right) received nutrient containing 100 parts per million sodium whereas crocks 2, 4, and 6 received nutrient containing 200 parts per million sodium. Left to right in Figure 1 are: low and high sodium respectively (crocks 1 and 2) with Topa Topa seedlings that show no leafburn; crock 3 (Harmon), no leafburn; crock 4 (Harmon), very severe leafburn at the high sodium concentration; crock 5 (Mexicola) slight leafburn, and crock 6 (Mexicola) with severe leafburn at the high sodium level.

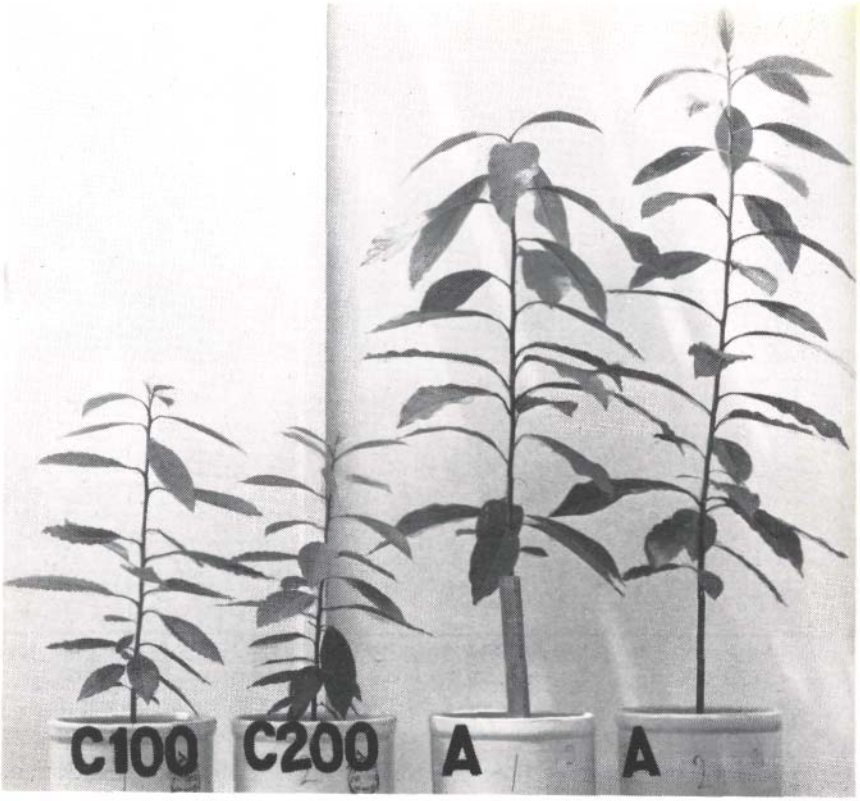

Fig. 2. *Effect, on June 25, 1952, on Caliente (C), and Anaheim (A) avocado seedlings planted in three-gallon-capacity sand cultures, of using 100 and 200 p.p.m. of sodium respectively as the nitrate to the nutrient solution. No leaf injury occurred. Ruler in crock 3 (left to right) represents one foot.*

Figure 2 shows the cultures (left to right) of Caliente (C) and Anaheim (A) avocado seedlings that received nutrient containing 100 and 200 p.p.m. of sodium respectively and added as the nitrate and in no case (on June 25, 1952) was there any leafburn.

In Figure 1 it was pointed out that at 100 p.p.m. of sodium in the nutrient solution the leaves of the Mexicola avocado seedling showed slight tip-burn and the faintest marginal leafburn whereas at the 200 p.p.m. sodium level the Mexicola leaves showed considerable injury. The extent of this sodium damage on June 25, 1952 (seedlings planted January 31, 1952) is more clearly shown in Figure 3.

Fig. 3. *Enlargement of leaves of the Mexicola avocado seedlings shown in Figure 1. Left, initial stage of perceptible marginal leafburn when the nutrient solution contained 100 p.p.m. of sodium added as sodium nitrate. Right, severe marginal leafburn at the 200 p.p.m. sodium level.*

Enlargement of the leaves of the Harmon avocado seedlings shown in Figure 1 more clearly reveal the degree of injury that resulted when 100 and 200 p.p.m. of sodium respectively were added as the nitrate to the culture solution. Although at 100 p.p.m. of sodium (Fig. 4) the injury consists of a slight tipburn, at 200 p.p.m. the injury is very pronounced.

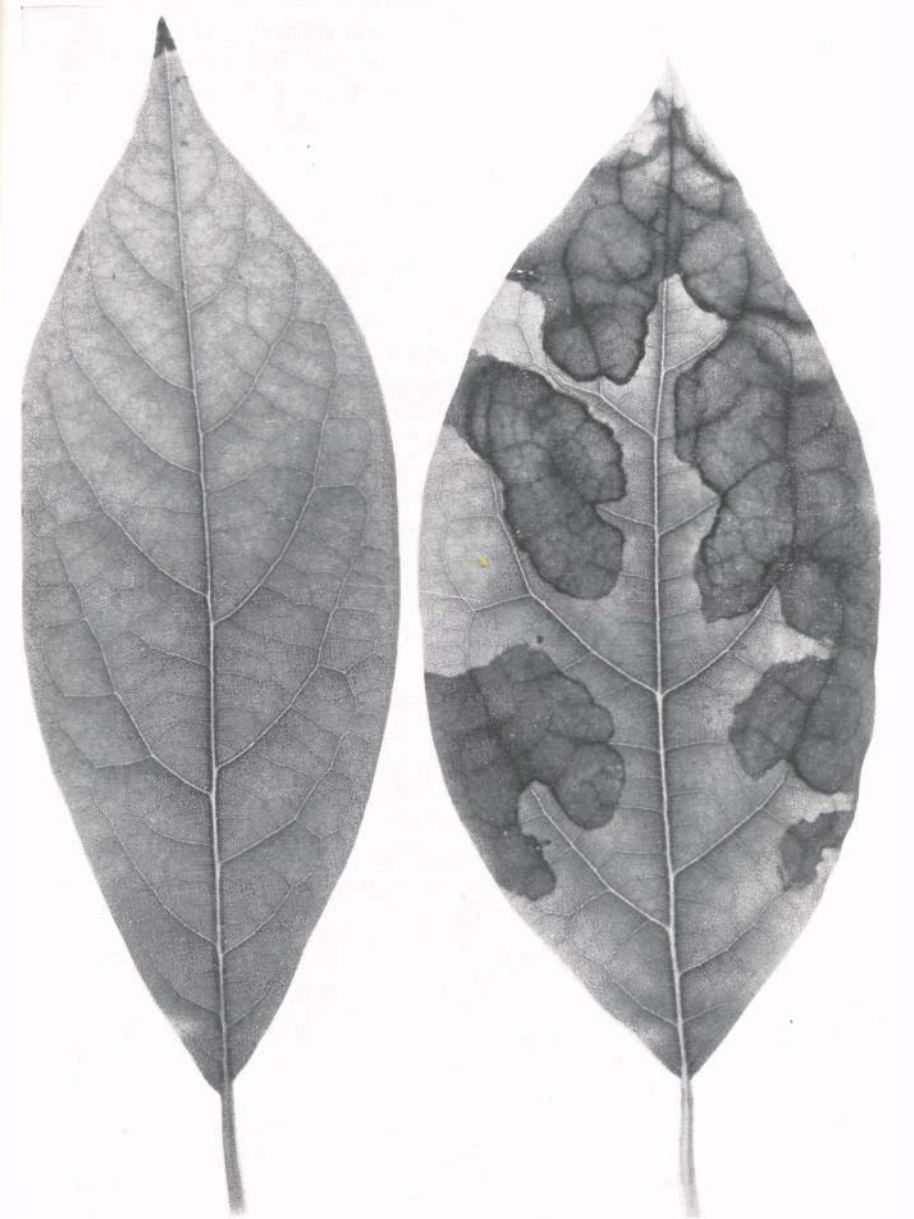

Fig. 4. *Enlargement of leaves of the Harmon avocado seedlings shown in Figure 1. Left, slight tipburn at 100 p.p.m. of sodium and right, progressively severe injury at 200 p.p.m. of sodium.*

On September 9, 1952, after a prolonged hot summer in the glasshouse, the mature leaves of the Topa Topa avocado seedlings showed a minor brown spotting at both sodium concentrations. The seedlings of the Caliente variety showed considerable brown spotting at both sodium levels but no continuous leaf burn. At 100 p.p.m. sodium the leaves of the Harmon avocado seedling showed slight burn with very severe leafburn at 200 p.p.m. sodium. Outstanding were the Mexicola avocado seedlings for the severity of leaf injury from sodium concentrations: at 100 p.p.m. of sodium the leaves showed considerable burn whereas at the 200 p.p.m. sodium level the injury was very severe. In both the Harmon and Mexicola avocado leaves at both sodium levels,

the leafburn was of the continuous marginal type.

In marked contrast to the behavior of these avocado seedlings of the Mexican race was that of the Anaheim avocado seedlings (Guatemalan race) which showed no leafburn whatsoever at either the 100 or 200 p.p.m. sodium levels. The Anaheim seedlings appeared very healthy, the leaves being large and dark green; their trunks were 53 and 60 inches respectively in height whereas those of the Mexican race of seedlings ranged from 19 to 29 inches. When the experiment was concluded on September 9, 1952, the lowermost few leaves that touched the nutrient solution containing the sodium nitrate were discarded and the mature leaves above these were collected for chemical analysis. The entire root system (cotyledons discarded) was taken as the root sample. Table 1 gives the average values of closely agreeing duplicate determinations of some of the inorganic constituents in the dry matter of the mature leaves and of the entire root system.

At the 100 p.p.m. sodium level the sodium contents of the leaves of the Harmon, Topa Topa, and Caliente avocado seedlings are relatively low and quite similar whereas that of the leaves of the Mexicola seedling was very high. With 200 p.p.m. of sodium in the nutrient solution the sodium contents of the leaves of both the Harmon and Mexicola avocado seedlings were very high. In the case of the Mexicola and Harmon varieties the increased sodium in the leaves was accompanied by a decrease in the calcium and magnesium.

Leaves of the Anaheim avocado seedlings (Guatemalan) contained the least sodium in their leaves of any of the cultures and their leaves had the healthiest appearance. The low sodium content in the leaves of the Anaheim avocado variety raises the question as to whether the root system of this variety absorbs the sodium, for if it does, then it must be that the sodium is largely retained by the root system and not transferred into the leaves. Table 1 indicates that the root system of the Anaheim avocado seedlings absorbed considerable sodium and largely retained it (very little sodium reaching the leaves) whereas in the Mexicola avocado seedlings the considerable sodium absorbed by the root system was largely passed on into the leaves with a resulting increased leaf injury.

This type of experimentation is being continued with soil cultures and with equal representation among the varieties of the Mexican and Guatemalan avocado races. For some orchards in which sodium is a problem, the selection of possibly sodium-resistant rootstocks may be of considerable importance.

TABLE 1

Effect of sodium (added as nitrate to the culture solution) on the inorganic composition of avocado leaves and root system of seedlings of the Mexican and Guatemalan races.

Variety of seedlings	Concentration of sodium (p.p.m.)	Per cent in dry matter of leaves				Per cent in dry matter of roots	
		Ca	Mg	K	Na	K	Na
MEXICAN RACE							
Mexicola	100	1.794	0.598	1.433	0.469	1.573	0.308
Mexicola	200	1.323	0.445	1.238	0.890	1.792	0.313
Harmon	100	1.588	0.548	1.242	0.088	1.039	0.626
Harmon	200	1.289	0.468	1.497	0.944	1.156	0.606
Topa Topa	100	2.215	0.736	1.117	0.099	1.124	0.597
Topa Topa	200	2.130	0.742	1.415	0.103	1.182	0.966
Caliente	100	1.449	0.551	1.913	0.070	1.132	0.424
Caliente	200	1.820	0.618	2.053	0.072	0.954	0.657
GUATEMALAN RACE							
Anaheim	100*	1.999	0.653	1.229	0.051	1.026	0.708
Anaheim	200**	2.445	0.725	1.297	0.043	0.780	0.864

*Ca and Mg percentages in the dry matter of the root system were 0.456 and 0.250 respectively.

**Ca and Mg percentages in the dry matter of the root system were 0.509 and 0.294 respectively.

LITERATURE CITED

1. *Ayers, A. D. Salt tolerance of avocado trees grown in culture solutions. Calif. Avocado Soc. Yearbook 1950: 139-148.*
2. *Ayers, A. D., D. G. Aldrich, and J. J. Coons. Sodium and chloride injury of Fuerte avocado leaves. Calif. Avocado Soc. Yearbook 1951: 174-178.*
3. *Haas, A. R. C. Effect of sodium chloride on Mexican, Guatemalan, and West Indian avocado seedlings. Calif. Avocado Soc. Yearbook 1950: 153- 160.*
4. *Haas, A. R. C. Calcium in relation to the effects of sodium in avocado seedlings, Calif. Avocado Soc. Yearbook 1950: 161-168.*
5. *Haas, A. R. C. Sodium in Lisbon lemon trees grown in soil cultures. Part I. Effect on growth, yield, and leaf composition. Citrus Leaves 32 (10): 10, 11, 26, 1952; Part II. Effect on composition of scion bark, root bark, and of rootlets. Citrus Leaves 32 (11): 12, 13, 32, 1952; Part III. Effect of sodium on the reproductive or fruit tissues. Citrus Leaves 32 (12): (In press), 1952.*