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Growth of the Avocado Tree in Solution Culture

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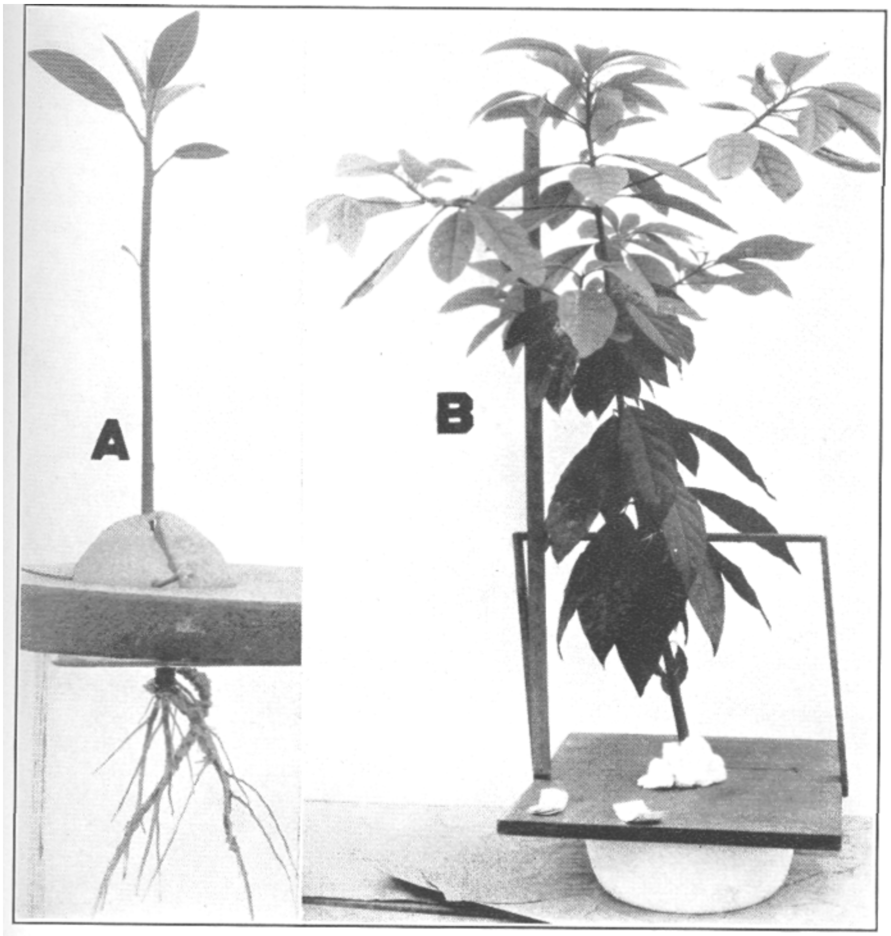
Most everyone who grows avocado trees in the field has at one time or another attempted to sprout the seed. When this is done for commercial purposes the seed are placed in soil or in other seed bed material. When, however, plants are desired for decorative purposes, the seed are placed in the mouth of a bottle filled with water that barely covers the base of the seed. If the bottle opening is wide the seed is held in place by means of several nails or wooden sticks inserted horizontally part way into the seed. This is illustrated in figure 1A.

Tap water, because of the salts it ordinarily contains, is preferable to distilled water for the growth of such seedlings. Unless light is excluded from the glass jar by means of a paper wrapper, green algae soon begin to grow unless they have been destroyed in the domestic water by means of chemical treatment. It is at this stage that the difficulties in the growing of avocado trees in solution culture really begin.

When light is excluded, the green algae fail to grow in the water and soon the avocado seedling does likewise. Green algae, by the processes involved in photosynthesis, give off oxygen into the water. Primarily on account of this oxygen supply and the attendant changes, the seedling with the roots unprotected from the light, lives the longer. Oxygen appears to be one of the most important elements necessary for the growth of avocado trees as was previously emphasized[1].

Regardless of the presence or absence of green algae the seedling soon becomes injured because of the need for fertilizer salts in the solution. The purpose of the interest of the author in growing trees in this way lies in the fact that by adding chemically pure salts to the distilled water or tap water (of known composition) and aerating the solution, it is possible to follow the response of the tree by observing the nature of the growth that results. This has not been done heretofore with avocado trees. By such means it may be possible to learn something in regard to the nutrient needs of the tree and possibly help explain some of the physiological troubles with which the avocado tree occasionally is afflicted.

The present paper reports the method of growing healthy avocado trees in solution cultures. Figure 1B shows the growth of a seedling of the Anaheim variety in a culture solution. The seedling was started as previously described. When the roots were several inches in length, the seedling was transferred to a hole two and one-quarter inches in diameter in a cover of wood placed over a shallow enamelware pan of 5 gallons capacity. The pan was filled with a solution into which air was passed.



Growth of avocado trees in solution cultures: A, Seedling of the Puebla variety starting growth while held in place with nails in the hole of a wooden cover on a wide-mouth jar filled with tap water; B, Seedling of the Anaheim variety growing in a culture solution containing chemically pure salts. The ruler is a meter (39.37 inches) in length.

SOLUTIONS USED

The stock solutions consisted of the following c. p. chemicals dissolved in distilled water: **A**, 133.3 grams potassium nitrate (KNO_3), 200 grams magnesium sulfate ($MgSO_4 \cdot 7H_2O$), and 6.1 grams of sodium chloride (NaCl), in a volume of 2 liters; **B**, 288.8 grams calcium nitrate ($Ca(NO_3)_2 4H_2O$) in 2 liters; **C**, 100 grams potassium acid phosphate (KH_2PO_4) in 2 liters; **D**, 247.4 grams potassium nitrate (KNO_3) in 2 liters, **B2,** 50.7 grams boric acid (H_3BO_3) in 2 liters; **B3,** 30.6 grams manganese sulfate ($MnSO_4 \cdot 2H_2O$) in 2 liters; **Fe**, iron tatrate 5 grams in 1 liter. Of the other so-called minor elements used, the stock solutions were made as follows: **Cu,** 7.07 grams copper sulfate ($CuSO_4 \cdot 5H_2O$) in 2 liters and then 20 cc of this solution diluted to 1 liter as the final stock solution; Zn 65.5 grams zinc nitrate ($Zn(NO_3)_2 \cdot 6H_2O$) in 2 liters but more accurately made by dissolving 17.9 grams zinc oxide with acid; and **Al cit,** 7.205 grams aluminum citrate in 1 liter. For the preparation of the A-Y stock solution of minor elements reference should be made to the footnote on p. 184 in a previous publication[2].

The culture solution had the following composition (parts per million):

Na	K	Ca	Mg	Cl	NO_3	SO_4	PO_4	B	Mn	Fe
21	595	477	162	30	2356	648	105	0.5	6.2	0.1

The phosphate and its associated potassium (K=42, PO_4=105) were added to the solution a week or so before the culture solution was renewed. During the three weeks or more that the phosphate was omitted, the 108cc **Al cit** (aluminum citrate) were present in the culture solution which then contained 5 parts per million aluminum. The **Zn** (1 part per million zinc), the **Cu** (.05 parts per million copper) 50 cc A-Y (0.2 parts per million of other minor elements (Haas (2)) and .05 grams silicic acid (H_2SiO_3) were added to each 18 liters of culture solution as it was freshly prepared with the phosphate temporarily omitted. This temporary omission of phosphate appears to favor the health of the roots possibly by permitting a greater solubility of the so-called minor elements.

Figure 1B shows the extent of top growth. The leaves were healthy in appearance and were kept green by means of daily or occasional additions of more iron tartrate solution.

A seedling of the Spinks variety was grown in a similar container in the glasshouse and when 3 feet high the tree was transferred to a 12 gallon-capacity earthenware jar placed on the ground. The culture solution contained in each 18 liter volume the following amounts of stock solution:

99 cc **A**, 234 cc **B**, 54 **C**, 16 cc **D**, 2 cc **B2**, 25 cc **B3**, and 23 cc **Fe,** The culture solution had the following composition (parts per million):

Na	K	Ca	Mg	Cl	NO_3	SO_4	PO_4	B	Mn	Fe
7	226	318	54	10	1278	216	105	0.5	6.2	0.1

The **C** solution was omitted until a week or so prior to the renewal of the solution and during the three week interval when **C** was absent, 108 cc **Al cit** (aluminum citrate) solution was used. The pH of the culture solution was 6.1.

CONTINUOUSLY AERATED

The solution was continuously aerated. Failure to aerate avocado solution cultures for a day or two caused wilting of the new top growth and when such cultures were again aerated the wilting was overcome but the growth of the new shoots was retarded and the root tips were injured.

The seedling tree of the Spinks variety grew until its top extended through the roof of the glasshouse. By taking advantage of cool foggy weather it was unnecessary to protect the tree when transferred outside of the glasshouse. When the experiment was concluded the circumference at the base of the trunk was 3 inches, the height of the top 6 feet two inches and the diameter of spread of the top was 6 feet.

Obviously the avocado tree can be grown in distilled water to which chemically pure salts are added. Moreover these salts may vary greatly in kind and amount without affecting the health of the tree. Thus far young trees have been grown successfully by adding boron, manganese, and iron of the so-called list of minor elements to the common salts used for culture solutions and by having aluminum present during the period of omission of the phosphate. As larger trees are grown it is likely that zinc, copper and traces of other elements will also be found essential. The small amounts of these elements present as impurities in the salts used for making culture solutions may be sufficient for small young trees, but inadequate for larger ones.

Instead of aluminum citrate, the nitrate salt may be used and in that case the vegetative growth of the trees also is normal without the presence of organic matter in the nutrient solution. However, organic matter in soil has advantages that cannot be discussed here. Since it has been seen that healthy trees may be grown in culture solutions, it therefore becomes possible to study the absorption by the roots. Also by varying the ratio and form of the salts used, the resulting growth changes in the tree may be followed.

[1]Haas, A. R. C. Soil aeration for avocado roots. California Avocado Assoc. Yearbook 1935, p. 56. 1935.

[2]Haas, A. R. C. Injurious effect of manganese and iron deficiencies on the growth of citrus. Hilgardia 7:181-206. 1932.