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Importance of Leaf Retention to Rooting of Avocado Cuttings[1,2]

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ABSTRACT. **Cuttings of 10 different clones of avocado *(Persea americana* Mill.) were rooted under intermittant mist. A wide range in rooting capability was noted. Rooting percentage of clones was found to be correlated with number of leaves retained on the cuttings. Speed of rooting within the same clone was also determined by number of leaves retained. Carbohydrate content in leaves and cutting bases at the beginning was not associated with rooting capability. Starch accumulation at the cutting bases occurred while cuttings were under mist; this was correlated with the rooting capability. Mineral (N, P, K, Ca, Mg, Na, Cl, B, Fe, Zn, Mn) content of the leaves at the beginning and after awhile under the mist did not show any association with rooting except for Mn, which was negatively correlated with rooting capability.**

Attempts to use conventional methods for rooting avocado cuttings have met with but limited success (7, 8, 10, 19). Etiolation of cutting bases before inducing rooting, with or without grafting on a seedling, is a potential method for overcoming the difficulties (4, 5, 6). Even with this method, differences in rooting capability are expected, as found by rooting non-etiolated cuttings under intermittent mist (10). Mexican-type clones root relatively easily, West Indian types are very difficult to root and Guatemalan types are intermediate in their behavior.

The purpose of the present study was to determine if a common factor(s) is associated with the rooting capability of different avocado clones. Cuttings of 10 different clones were rooted on a large scale under the same conditions, in order to obtain representative results, previous observations had revealed that rooting of avocado cuttings is associated with leaf retention (10, 11, 19), as with other leafy cuttings (9). It was decided to study more carefully whether this factor is common to different clones, and also to study the role of leaves in the rooting process. The potential contribution of leaves was studied from 3 different aspects: (i) as a source of carbohydrates which accumulate at the base of the cuttings and are an important factor in the rooting process (16); (ii) as containing different nutritional constituents which might influence rooting (13)

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(this possibility was considered since differences in selective ion uptake exist among races and clones of avocado (2)); and (iii) as a source of rooting factors. Results of the last aspect of the study will be reported separately.

Materials and Methods

Cuttings of the 10 different clones (Table 1) were rooted under intermittent mist with bottom heat kept at 25±1°C. Semi-hard wood cuttings 20-25 cm long were collected in October from mature mother trees grown under similar conditions. A uniform number of 7 leaves was left on each cutting. There were 64 cuttings for each clone, arranged in 8 split blocks, and 8 cuttings per replication. Data were submitted to statistical analysis using Duncan's multiple-range test.

Table 1. Rooting, leaf retention, and survival of different races of avocado cuttings after 9 months under intermittent mist.

Clone	Race[z]	Cutting survival % Rooted	Cutting survival % Died	Leaves retained (%)
Northrop-28/5	M[z]	89 a[y]	7	69
Glickson-7/H	M	81 ab	8	54
Benik-31/6	G	71 b	24	32
Gvaram-13	M (?)	49 c	35	30
Fuchs-20	W x G	17 d	77	4
Lula- 3	W x G	13 de	63	17
Hall-30	W x G	6 de	89	4
Nabal-D	G	1 e	83	3
Maoz	W	0 e	100	0
Nahlat-7	W	0 e	100	0

[z]M = Mexican, G = Guatemalan, W = West Indian

[y]Mean separation by Duncan's multiple range test at 5% level.

Leaves and cutting bases were sampled at the beginning of the experiment and 5 weeks later, for endogenous analyses. Cutting bases were 2 cm long and were separated into bark and wood. Samples were frozen immediately in liquid nitrogen, lyophilized, ground and stored in a deep freezer (-18°C) until analysis. Carbohydrates were determined (12), and mineral content of leaves was analyzed after calibration and slight modifications of methods described for different elements (1, 3, 14).

Results and Discussion

Cuttings of easy- and intermediate-to-root clones started to root first. After 2 months, 33% of the 'Northrop-28/5' and 16% of 'Gvaram-13' cuttings were rooted. From the third month on, rooting started at a greater speed as given in Fig. 1. The cuttings were kept under the mist for 9 months in order to obtain the full rooting potential capability of the different clones. A great difference in rooting capability was noted at the termination of the experiment (Table 1). The wide range obtained among the 10 clones was used to find correlations between different parameters and rooting capability.

It was observed from the beginning of the experiment that cuttings of the difficult-to-root clones shed their leaves in 5 to 10 weeks and died afterwards. Leaves on cuttings of easy-to-root clones were retained up to 9 months when the experiment was terminated. Complete data on leaf shedding with time are not presented here; only the results recorded at the termination of the experiment, which represent very well the tendency with time, are given in Table 1. In another experiment where all leaves were removed from cuttings of an easy-to-root clone (Northrop-28/5), none of them rooted and they died after a short time. The contribution of leaves in determining the rooting process or its speed is pronounced even among different cuttings of the same clone: those which retained their leaves for a longer period rooted faster (Table 2). The results show that retention of leaves on avocado cuttings is essential for rooting. And rooting percentage of different clones was found to be correlated with number of leaves retained (Fig. 2). It seems, therefore, pretreatment of the cuttings before or while under the mist, in order to reduce leaf shedding, might lead to a higher rooting percentage. It is known cuttings taken from juvenile plants retain their leaves for a longer time, which may explain, partially, why such cuttings root more easily than others (15).

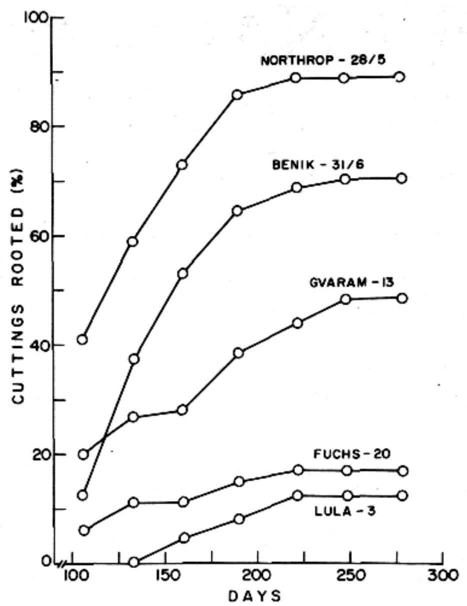

Fig. 1. Cumulative percentage of rooted avocado cuttings of different clones with time under intermittent mist.

The contribution of leaves to the rooting process can be explained in different ways, one of which is the continuation of photosynthesis under mist which leads to an accumulation of carbohydrates at the base of the cuttings. At the beginning of the experiment, carbohydrate content of the different tissues assayed was not found to be associated with rooting capability. A completely different situation was found 5 weeks later. Sucrose content was higher in all of the clones at the base of the cuttings and lower in the leaves. Amounts of reducing sugars and starch were greater in leaves as well as in the cutting bases. The more significant accumulation was of starch; the initial level being less than 1% at the beginning and rising after 5 weeks to 5% (dry wt.) and above. Starch accumulation was higher at the base of the easy-to-root cuttings and was found for both the wood (Fig. 3) and bark (r=0.68) tissues. The importance of a high carbohydrate content at the site of rooting has been shown in many other cuttings, and generally wherever morphogenetic processes take place (16, 18). Avocado cuttings do not differ from other leaf cuttings in this respect (9). The effect of nutritive status of the cuttings on rooting of the different clones was studied by detecting mineral content of the leaves. At the beginning, and after 5 weeks under the mist, mineral element content of the leaves did not show differences associated with rooting except for Mn. Its content was negatively correlated with the rooting capability (Fig. 4). There was a general tendency for leaf mineral content to change while under the mist. There was a significant decrease in K, Mg, and B, a small decrease in N, P and Mn; and an increase in Na, Zn, Ca, Fe and Cl (Table 3). Only Mn of the 11 elements analyzed was found to be associated with rooting capability. It seems that a high Mn content in leaves might interfere with rooting. This element is known as an activator of IAA-oxidase (17). A low content of IAA would be expected as a result of its activity. This might lead to earlier leaf shedding and a smaller accumulation of the auxin at cutting bases. It is possible, therefore, that Mn activates enzymes which might interfere with rooting, directly or indirectly. The mode of action and the more specific involvement in rooting of this element deserve further attention. From the practical point of view, it seems worth trying to reduce the content of Mn in leaves of mother plants from which cuttings are taken.

Table 2. Average number of leaves on rooted and non-rooted avocado cuttings after different times under mist.

	Avg no. of leaves					
	133 days under mist		190 days under mist		222 days under mist	
Clone	Rooted	Non-rooted	Rooted	Non-rooted	Rooted	Non-rooted
Northrope-28/5	6.0±0.3[z]	4.3±0.3	4.6±0.3	3.8±0.4	4.4±0.3	1.8[y]
Gvaram-13	4.5±0.5	2.6±0.2	2.4±0.5	1.5±0.2	2.4±0.3	0.6±0.3

[z]±SD.

[y]Few cuttings left did not enable calculation of SD.

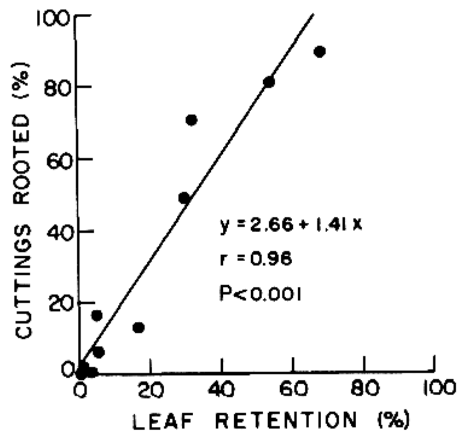

Fig. 2. Correlation between leaves retained on cuttings of different avocado clones and the rooting percentage.

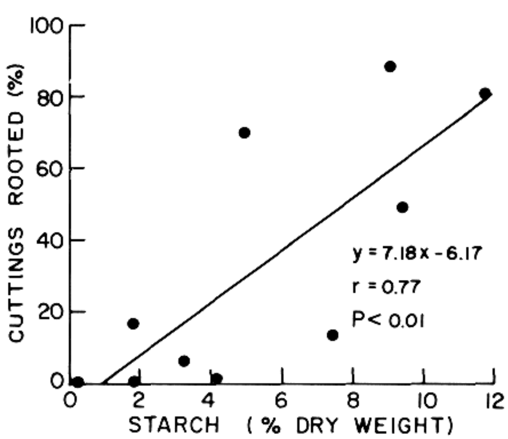

Fig. 3. Correlation between starch accumulated at cutting bases of different avocado clones and the rooting percentage.

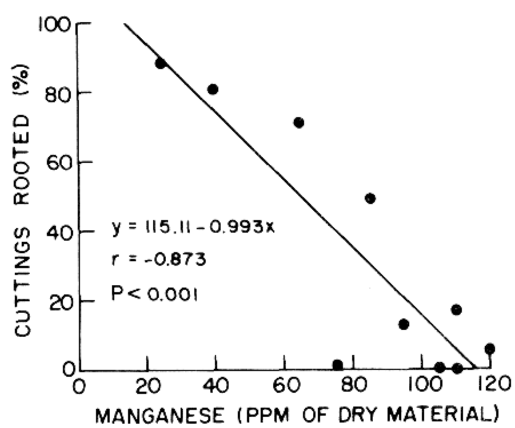

Fig. 4. Correlation between manganese content of leaves of different avocado clones and rooting percentage.

Table 3. Average mineral content of avocado cuttings leaves at beginning and after 5 weeks under mist.

Sampling time	Dry wt (%)							Dry wt (ppm)			
	N	P	K	Ca	Mg	Na	Cl	B	Fe	Zn	Mn
At beginning	1.77±0.07[z]	0.14±0.007	0.93±0.13	0.94±0.10	0.54±0.04	0.02±0.001	0.22±0.04	44±5	106±12	43±2	83±10
After 5 weeks	1.52±0.07	0.11±0.005	0.69±0.07	1.65±0.13	0.27±0.03	0.06±0.005	0.28±0.04	27±3	191±19	459±81	79±11

[z]SD.

Literature Cited

1. Association of Official Agricultural Chemists. 1960. Official methods of analysis. Association of Official Agricultural Chemists, Washington, D.C.
2. Ben-Ya'acov, A. and R. Spodheim. 1968. Cation exchange capacity of the roots of avocado plants of different salinity susceptibility. *Israel J. Bot.* 17:125-126. (Abstr.)
3. Boltz, D. R. (ed.). 1958. Colorimetric determination of non-metals. Interscience Publishers, New York.
4. Brokaw, W. H. 1977. Subtropical fruit tree production; avocado as a case study. *Proc. Intern. Plant Prop. Soc*. 27:113-121.
5. Ernst, A. A. And C. Holtzhausen. 1978. New promising technique for rooting difficult-to-root avocado *(Persea americana* Mill.) cuttings. *Citrus Subtrop. Fruit J.* 532:6-10.
6. Frolich, E. F. And R. G. Platt. 1971. Use of the etiolation technique in rooting avocado cuttings. *Yearb. Calif. Avocado Soc*. 55:97-109.
7. Gillespie, H. L. 1957. Stem-rooting clones by means of "juvenile growth phase" leafy-stem cuttings. *Yearb. Calif. Avocado Soc*. 41:94-96.
8. Gustafson, C. D. and A. Kadman. 1969. Effect of some plant hormones on the rooting capability of avocado cuttings. *Yearb. Calif. Avocado S*oc. 53:97-100.
9. Hartman, H. T. and D. E. Kester. 1975. Plant propagation, 3rd ed. Prentice-Hall, Englewood Cliffs, N.J.
10. Kadman, A. and A. Ben-Ya'acov. 1965. A review of experiments on some factors influencing the rooting of avocado cuttings. *Yearb. Calif. Avocado Soc.* 49:67-72.,
11. Leal, F. and A. H. Krezdorn. 1964. Rooting avocado cuttings. Proc. Fla, State Hort. Soc. 77:358-362.
12. Reuveni, O. and Y. Adato. 1974. Endogenous carbohydrates, root promoters, and root inhibitors in easy and difficult-to-root date palm (*Phoenix dactylifera* L.) offshoots. *J. Amer. Soc. Hort. Sci*. 99:361-363.
13. Samish, R. M. and P. Spiegel. 1957. The influence of nutrition of the mother vine on the rooting of cuttings. *Ktavim* 8:93-100.
14. Sandell, E. B. 1959. Colorimetric determination of traces of metals. Interscience Publishers, New York.
15. Schaffalitzky de, M. 1954. Juvenile stages in woody plants. *Physiol. Plant* 7:782-796.

16. Stoltz, L. P. and C. E. Hess. 1966. The effect of girdling upon root initiation, carbohydrates and amino acids. *Proc. Amer. Soc. Hort. Sci* 89:734-743.

17. Thomaszewski, M. and K. V. Thiman. 1966. Interaction of phenolic acids, metallic ions and chelating agents on auxin-induced growth. *Plant Physiol.* 41:1433-1454.

18. Thorpe, T. and T. Murashige. 1970. Some histochemical changes underlying shoot initiation in tobacco callus cultures. *Can. J. Bot.* 48:277-285.

19. Young, L. B. 1961. Vegetative propagation of avocados by means of marcottage and the rooting of cuttings. *Yearb. Calif. Avocado Soc*. 45:63-66