

cultural equipment for nontillage was \$20,025, as compared with \$23,350 for the tillage system.

A detailed cost analysis for the nontillage system is shown in the table. The total cost per acre under nontillage was \$496.69, as compared with \$517.28 per acre for the conventional tillage method. This meant a saving of \$20.46 per acre, or per ton, in this case. The savings were possible mainly through the substitution of mowing and weed spraying for the usual methods of soil management. Additional savings resulted from the elimination of a soil-sealing irrigation prior to harvest and through lower overhead costs for equipment.

Tillage costs

Specific deviations for the tillage system, as compared with the nontillage method shown in the table include elimination of the five starred items in the first part and substitution of two items: (1) Cultivate 16X, figured at 5 hours per acre with labor costs of \$11 and fuel and repair costs at \$6 for a total cost of \$17 per acre; and (2) hoe around trees, figured at 1.7 hours per acre with labor costs of \$3 per acre.

Three irrigations were used under the nontillage system for a total of \$16.20 per acre, as compared with four irrigations (including the soil-sealing irrigation) under a tillage program for a total of \$20.10 per acre.

Total hours and cultural cost figures for tillage were \$191.12, compared with \$176.83 per acre for the nontillage system. Miscellaneous overhead expenses were figured at \$10.98 for tillage as compared with \$10.27 shown in the table for nontillage. These changes brought the total cash costs for tillage to \$257.60 instead of \$242.60 as shown in the table for nontillage. Per acre costs for cultural equipment (under investment) were \$292 per acre for tillage with depreciation figured at \$29.20 and interest at \$8.76 for a total investment cost of \$229.55, as compared with \$224.09 for nontillage. Total costs per acre (including investment) were \$517.28 for tillage, as compared with \$496.69 for nontillage. Costs per pound of almonds produced (figuring a 2000 lb per acre yield) came to 25.9 cents for tillage, as compared with 24.8 cents for nontillage.

Clem Meith is Farm Advisor, Butte County; and Phil Parsons is Extension Economist, University of California, Davis.

PROPAGATION of Apple Rootstocks by Hardwood Cuttings

H. T. HARTMANN • C. J. HANSEN • F. LORETI

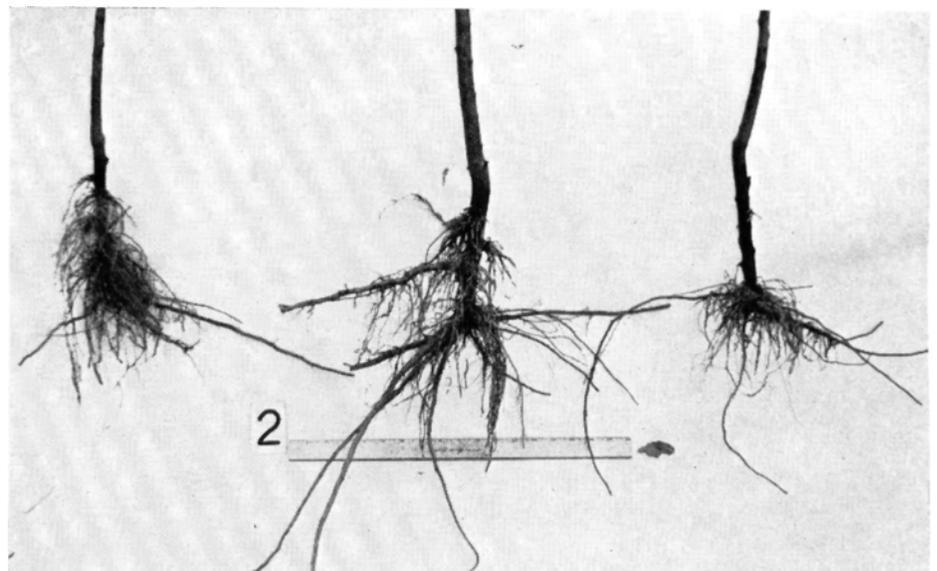
Excellent nursery trees of several clonal apple rootstocks were produced in these tests 11 months after hardwood cuttings were planted. Preplanting treatments with indolebutyric acid followed by bottom heat at the base of the cuttings, while the tops were exposed to normal winter chilling, were necessary. This method could replace the more expensive and slower "stooling" method of propagating clonal apple rootstocks.

IN MANY APPLE-growing regions of the world, clonal, self-rooted rootstocks are used to propagate new trees rather than apple seedlings. Such clonal stocks are largely the East Malling and Malling-Merton size-controlling stocks selected and developed at the East Malling Research Station and the John Innes Horticultural Institution, both in England. In the past, these rootstocks have usually been propagated by the "stooling" or mound-layering method in which soil is mounded up around the young shoots arising from the base of the mother plant.

These shoots form roots during the growing season and after they become dormant are cut off to be lined out in the nursery for another season's growth. This method is slow, cumbersome, and expensive. On the other hand, propagation by hardwood cuttings is fast and inexpensive.

In the trials reported here, studies were made of the propagation of several apple rootstocks by the use of hardwood cuttings. Cutting material obtained from Oregon was made into hardwood cuttings on January 2, 1964. The cuttings were

Photo 1. Root system of Malling-Merton 111 apple rootstock 12 months after starting from hardwood cuttings. Length of rule is 18 inches.



made from one-year-old wood sawed to a length of 8 inches by a band saw. Prior to further treatment, the bases of the cuttings were soaked in an indolebutyric acid solution in water at 100 ppm (parts per million) for 24 hours. Three methods of handling were subsequently used for each clone: (1) planting directly in the nursery row, (2) storing the cuttings in damp peat moss at 70 degrees F (21 degrees C) for about three weeks before planting, and (3) placing the cuttings over bottom heat at 70 degrees F in a covered outdoor bed, where the top buds would be chilled, for about three weeks before planting.

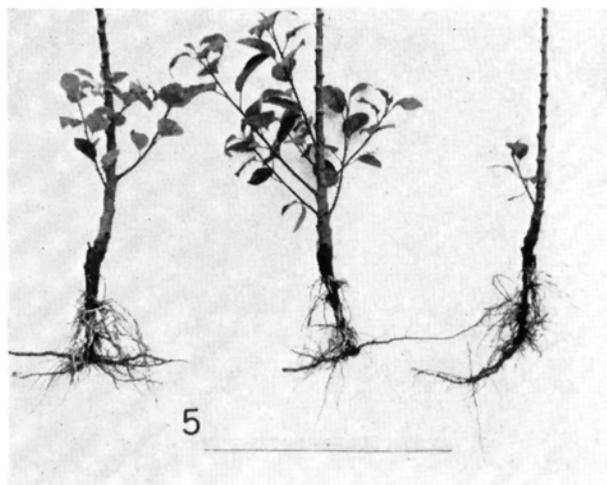
Cutting treatments

Cuttings given the first treatment were planted in the nursery on January 3, while those receiving the second and third treatments were planted January 27. In treatment 1 the cuttings were inserted by pushing them into loose, previously rototilled soil to a depth of about 7 inches. In treatments 2 and 3, where a heavy callus and—in some instances—short roots had developed at the base of the cuttings by the time of planting, the cuttings were carefully placed in a trench and covered with soil to a depth of 7 inches. Soil temperature at the base of the cuttings was about 45 degrees F (7 degrees C) in January at Davis, California.

The table lists the clonal rootstocks given these treatments and shows the rooting results obtained. Approximately 90 cuttings were used for each individual treatment, divided into three replicates, each planted in different areas in the nursery. Best rooting was obtained with E.M. IX, E.M. VII, E.M. 26, and M.M. 111 by the third method of handling the cuttings—IBA treatments followed by a callusing period over bottom heat while the top buds were chilled. Very little rooting of hardwood cuttings of M.M. 104 was obtained by any of the treatments. The results obtained with M.M. 106 were somewhat erratic; while the highest rooting with this clone occurred with treatment 3, it was not significantly superior to the other two. Generally very poor rooting was obtained with cuttings of any of the clones when they were planted directly in the nursery row (treatment 1).

Excellent nursery trees were produced eleven months after the cuttings were made. Photo 3 shows the appearance of trees of M.M. 111 in November, 1964. Photo 1 shows the root system developed by December, 1964. Photo 2 shows the

Photo 2. Root system of East Malling IX apple rootstock 12 months after starting from hardwood cuttings. Length of rule is 18 inches.



root system produced by the hardwood cuttings of E.M. IX.

Commercially, these nursery rootstock trees would be large enough for fall budding to the desired top variety by late July or August. They would then be grown in the nursery for an additional season to produce the complete nursery tree, composed of the varietal top and the clonal rootstock.

H. T. Hartmann and C. J. Hansen are Professors, Department of Pomology, University of California, Davis. F. Loreti is Assistant Professor, Istituto di Coltivazioni Arboree, University of Pisa, Pisa, Italy.

Photo 3. Nursery trees of Malling-Merton 111 apple rootstock 11 months after starting from hardwood cuttings. Height of screen is 5 ft.



PROPAGATION OF CLONAL APPLE ROOTSTOCKS BY HARDWOOD CUTTINGS

THE CUTTINGS, MADE JANUARY 2, 1964, WERE TREATED WITH INDOLEBUTYRIC ACID AT 100 PPM FOR 24 HOURS. NINETY CUTTINGS PER TREATMENT.

Clone	Per cent of cuttings rooted			Difference required for significance:	
	Treat. 1* ‡	Treat. 2† ‡	Treat. 3‡	5% level	1% level
E.M. IX	0.0	1.0	19.7	5.5	8.2
E.M. VII	0.0	0.0	29.1	8.6	13.1
E.M. 26	16.6	43.9	63.6	7.8	11.9
M.M. 104	0.0	0.0	1.1	1.2	1.8
M.M. 106	17.1	3.4	28.7	25.6	38.8
M.M. 111	2.1	12.9	60.9	10.8	16.4
Difference required for significance:					
at 5% level					
at 1% level					

* Planted directly in the nursery.
† Held in damp peat moss at 70° F until roots appeared, then planted.
‡ Held over bottom heat at 70° F outdoors until roots appeared, then planted.