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MODERATOR LAGERSTEDT: Thank you, Dr. van Overbeek. Our next speaker on this evening's program will be Dr. Hudson T. Hartmann Professor of Pomology, University of California at Davis. Dr. Hartmann --

The Use of Growth Regulators in Propagating Clonal Rootstocks for Several Tree Fruit Species

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Clonal rootstocks are becoming more important each year in propagating many kinds of fruit trees. Such stocks have the advantages of uniformity, perpetuation of specific, desired characteristics without change, and often result in more rapid propagation time than when seedling stocks are used. They have the disadvantage, however, of perpetuating diseases -- so the use of initially clean stock is very important.

During the past few years in California, a definite need for clonal rootstocks, and rapid methods of propagating them, has arisen in several tree fruit species.

As a rootstock for the English walnut, Paradox walnut seedlings (*Juglans hindsii* x *J. regia*), resulting from natural crossing, have proved to be excellent, better in many instances than the usual *J. hindsii* seedlings. However, certain Paradox seedlings are far superior to others in vigor, resistance to nematodes, and to oak-root fungus. A method of developing clonal rootstocks from these certain seedlings would be of great value.

Studies have been going on in the Department of Pomology, University of California, for about ten years in efforts to develop satisfactory methods of rooting Paradox walnut clones. The problem has proven to be quite difficult. Both leafy, soft-wood cuttings under mist and woody hardwood cuttings have been used. In each case, treatment with a growth regulator - indolebutyric acid - was essential for rooting. Without such treatments not a single instance of root formation occurred. Table 1 shows typical results obtained in rooting tests with soft-wood cuttings under intermittent mist (2). Paradox walnut softwood cuttings, while rooting readily under mist, do not survive easily after rooting. Any disturbance of the root system seems fatal. Tests in 1961 indicate that rooting in mist beds which permit root growth on down into soil under the bed, with removal only after the rooted cuttings go dormant in the fall, may prove to be a feasible means of obtaining survival.

Table 2 shows results of a test with hardwood Paradox walnut cuttings (1). To obtain rooting, the cuttings were set upright in boxes of damp peat moss. A pronounced temperature effect was noted; raising the temperature about 10 degrees during the 60-day rooting period greatly stimulated rooting. This method, while producing rooted cuttings, has its drawbacks, since large losses occur in moving the rooted cuttings to the nursery. Rooting does not take place if the cuttings are just planted in the nursery row due, no doubt, to the low soil temperatures occurring in the spring.

The pear decline disaster in California, Oregon, and Washington may possibly be overcome by the use of a particular decline-resistant clonal rootstock - the Old Home pear. Means of rapid propagation of this clonal stock was urgently needed to permit its large-scale use.

Tests in rooting Old Home pear hardwood cuttings have been very rewarding. By following certain procedures, good rooting and survival has been obtained. Treatments and results are shown in Table 3. Collection of the cuttings in the fall, treating with IBA, then storing in damp peat moss at warm temperatures (65£ to 70°F.) for about four weeks before planting resulted in good survival percentages (3,5). No rooting was ever experienced when the IBA treatment was omitted. Direct planting in the nursery in the fall was not successful even with IBA treatment due, no doubt, to the lack of warm temperatures at the base of the cuttings, needed to stimulate adventitious root formation. The four-week storage period at a 70° temperature did not force the buds into growth since they were still in the rest period. Cold weather the remainder of the winter, after planting in the nursery, served to break the rest period of the buds. Bud growth as well as root growth then started with the onset of warm weather in the spring.

The Stockton Morello cherry has long been known in California as an excellent clonal rootstock for the sweet cherry, being adaptable to heavy, poorly-drained soils and, at the same time, imparting a much-needed, semi-dwarfing effect to the tall-growing sweet cherry. The Stockton Morello, however, could only be propagated by using the few suckers arising around the trunks of older trees. In addition, this stock was heavily infected with viruses, (necrotic rusty mottle, ring spot, and sour cherry yellows). Work is underway by the Dept. of Plant Pathology, University of California, to eliminate these viruses by heat treatments. A rapid method of clonal propagation from these limited virus-free sources was urgently needed.

Stockton Morello leafy cuttings taken from very young shoots in the spring root readily under intermittent mist - but only if they are treated with IBA (4). Rooting can be obtained as long as the new shoots are in active growth, but as soon as shoot elongation stops and a terminal bud forms, rooting of cuttings taken from such shoots is very difficult. Possibly a naturally-occurring auxin is being produced in the actively-growing bud which stimulates root formation.

Hardening off the rooted cuttings is a problem. Attempts to move them into pots or into the nursery row generally are failures. Best results are obtained when the cuttings are left in the flats in which they were rooted, then moved gradually from the mist into the greenhouse, then into a lath house and left there with occasional treatment with a nutrient solution until they become dormant in the winter. The following spring they are lined out in the nursery row and develop into good nursery trees by the end of the summer. This may prove to be the best practice for handling cuttings of deciduous species rooted under mist since, to produce good nursery trees, two years probably would be required in any event with most species.

The Marianna 2624 plum, a vigorous seedling selection of the parent Marianna plum (Prunus cerasifera x P. Munsoniana), is widely used in California as a rootstock for plums, prunes, and apricots. This is commonly propagated by hardwood cuttings but sometimes, especially in heavy clay soils, good stands are difficult to obtain. As shown in Table 4, tests conducted with this clonal stock showed marked benefits from treatments with indolebutyric acid (3).

In the instances described here, the use of a growth regulator, particularly indolebutyric acid, was found to be essential in obtaining satisfactory rooting. The statement is often made that growth regulators are of no benefit unless the cuttings will root to some extent without them. This is certainly not the case with Paradox walnut or the Old Home pear hardwood cuttings. We have never had an instance of their rooting when IBA was not used. The statement is also heard sometimes that root-promoting substances are of no value for hardwood cuttings - only for leafy cuttings. This again has not proven true with the species used in these tests.

Of course, other factors must be considered in rooting cuttings aside from the use of growth regulators. Timing is often of the utmost importance. In the work described here, in rooting Old Home pear hardwood cuttings, excellent results are obtained under California conditions if the material is taken and planted in the fall. Spring planting gives almost 100% failure. In rooting soft-wood cuttings of cherries under mist, only the time between beginning of shoot development in the spring and the cessation of terminal growth in mid-summer is suitable for taking the cuttings. Many other cases of "timing" effects could, of course, be cited.

Temperature relationships are extremely important in rooting cuttings. The application of growth regulators to a cutting to stimulate root formation is of no value if the base of the cutting is plunged into cold soil where the temperature is so low that there is no cell activity.

Failure to obtain rooting of hardwood cuttings of difficult species when planted in the spring can often be attributed to temperature effects. The uppermost buds, exposed to the heat of the sun, soon become warm and open, followed by leaves which quickly withdraw the water from the cutting. The base of the cutting, several inches deep in the soil, at lower temperatures, is inactive - no roots develop, no water is absorbed to offset that removed by leaves, and the cutting soon dies. The age-old practice of callusing hardwood cuttings by storing upside down in out-of-door pits with the base of the cuttings several inches below the soil surface is based on sound physiological principles. Adventitious roots are stimulated by the higher temperatures of the warmer surface soil, while the buds are retarded by the lower temperatures of the deeper soil layers.

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TABLE 1. EFFECT OF INDOLEBUTYRIC ACID ON THE ROOTING OF PARADOX WALNUT SOFTWOOD CUTTINGS UNDER MIST. CUTTINGS TAKEN JUNE 16, 1956. 30 CUTTINGS PER TREATMENT.

CONCENTRATION OF IBA[1]	PERCENT OF CUTTINGS ROOTED	AVERAGE NUMBER OF ROOTS PER ROOTED CUTTING
0 PPM	0	--
2000	13	2.5
4000	23	5.0
6000	53	8.3
8000	60	7.3

[1] Applied by concentrated-solution-dip method.

TABLE 2. EFFECT OF INDOLEBUTYRIC ACID, BUD REMOVAL, AND WOUNDING ON THE PERCENT ROOTING OF HARDWOOD PARADOX WALNUT CUTTINGS. AFTER STORAGE IN PEAT MOSS FOR 60 DAYS.

CONCENTRATION OF IBA - 24 HR. SOAKING METHOD	BUDS REMOVED		BUDS NOT REMOVED	
	WOUNDED	NOT WOUNDED	WOUNDED	NOT WOUNDED
STORAGE AT 60°F				
0 PPM	0	0	0	0
100	0	0	0	0
200	0	0	0	0
300	13	13	13	7
STORAGE AT 70°F				
0 PPM	0	0	0	0
100	0	0	0	0
200	13	26	20	13
300	40	33	26	33
400	13	20	20	20

TABLE 3. PERCENTAGE OF OLD HOME PEAR HARDWOOD CUTTINGS WHICH PRODUCED VIGOROUS NURSERY TREES. 1959-1960.

TREATMENT	CUTTINGS MADE	ROOTED CUTTINGS		
		100*	200*	300*
TREATED WITH IBA AND PLANTED AT ONCE	NOV. 16	1.3%	2.6%	2.6%
	DEC. 15	1.3	0.0	0.0
	JAN. 15	0.0	0.0	0.0
TREATED WITH IBA, HELD IN WARM (65°F) STORAGE 3 WEEKS, THEN PLANTED	NOV. 16	37.3	53.3	42.7
	DEC. 15	24.3	35.1	24.3
	JAN. 15	0.0	13.5	8.1

*Base of cuttings soaked in IBA solutions - 100, 200, and 300 ppm for 24 hrs.

TABLE 4. EFFECT OF TIME OF COLLECTION, STORAGE, AND AUXIN TREATMENTS ON SURVIVAL AND GROWTH OF MARIANNA 2624 PLUM HARDWOOD CUTTINGS. THREE REPLICATES OF 45 CUTTINGS EACH PER TREATMENT, 1956-57.

DATE COLLECTED	HANDLING METHOD	TREATMENT IBA	% SURVIVAL	AV. TREE HEIGHT JULY 26, 1957
Oct. 2, 1956	Planted immediately	45 ppm*	56	83 cm
		Control	28	63
Oct. 2	Stored for 6 weeks at 60°F. Planted Nov. 13	45 ppm*	53	73
		Control	23	70
Nov. 13	Planted immediately	45 ppm*	79	96
		Control	29	73
Nov. 15	Stored for 6 weeks at 60°F. Moved to 36°F until planted Feb. 19	45 ppm*	95	100
Feb.12,1957	Planted immediately	45 ppm*	50	60
		Control	8	48
Feb. 12	Stored for 3 1/2 weeks at 60°F. Planted Mar. 8	45 ppm*	65	67
		Control	0	--
Feb. 12	Stored as shoots for 4 weeks at 32°F. Planted Mar. 13	45 ppm*	69	60
		Control	2	40
Difference required for significance at 1% level			32	17

*Base of cuttings soaked for 24 hours in indolebutyric acid, 45 ppm.

MODERATOR LAGERSTEDT: Thank you, Dr. Hartmann. We will now hear from Dr. George Oki, Oki Nursery Co., located at Perkins, near Sacramento, California. Mr. Oki --

Growth Regulators, The U. C. System, and the Oki Nursery

George Oki

Oki Nursery Company

Perkins, Sacramento County, California

A great deal of emphasis has been placed on rooting hormones since 1935. This, however, did not mark the beginning of the use of hormones. It has been said that Dutch propagators inserted a wheat grain into the split basal ends of cuttings over a century ago.

The wheat grain in germinating, releases an auxin, thus stimulating root growth. Auxin is another term for natural hormone produced by plants. Growth regulators as we know them today are synthetic auxins, with a purpose in mind, "to stimulate root growth".

Although auxins, or hormones, play a very important role in propagation today, there are many other factors equally, if not more important. In the preface of the University of California Manual 23, edited by Dr. Ken Baker, is a symbol of the U. C. System. Within this symbol, with a few minor changes, lies the identical basic rules of plant propagation. The changes are: