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ROOTING STUDY OF MATURE RED OAK AND BLACK WALNUT STEM CUTTINGS TREATED WITH HIGH CONCENTRATIONS OF IBA

by

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I. INTRODUCTION

Red oak, *Quercus rubra* L., and black walnut, *Juglans nigra* L., are important North American hardwood sawtimber species, and additionally, black walnut is the second most valuable native nut tree species, exceeded only by the pecan (24). The red oaks (*Quercus rubra* L., *Q. velutina* Lam., *Q. palustris* Muenchh., *Q. falcata* Michx., *Q. falcata* var. pagodaefolia Ell., *Q. texana* Buckl., *Q. nigra* L., *Q. phellos* L.) (17) yield slightly over 23% of hardwood sawtimber harvested in the eastern United States commercial forest land: Collectively, they are the single most important source of eastern hardwood (34). Furthermore, red oak (*Q. rubra*) is recommended for use in ornamental landscapes because of its rapid growth, ease of transplantation, and ability to withstand city growing conditions (30,39). Although black walnut is a relatively minor timber crop in all states, its distinctive beauty and durability has created a large domestic and rapidly expanding foreign market (24). This wide appeal, when coupled with the trend of greater cut than replacement growth, has resulted in the imposition of log export quotas (24).

However, until cutting propagation techniques are developed, genetically superior selections may not be clonally propagated in large numbers. Despite a projected shortage of hardwood sawtimber after 2000 (35), significant gains can be made in timber supplies by planting genetically improved stock (33). Methods to propagate superior black walnut clones are greatly needed for increasing timber production (23). Presently, genetic stock improvement is implemented by collecting and planting seed from superior tree selections (33), but only 15% of the reforestation seedlings grown in federal and state nurseries are of superior parentage (33). Additionally, progress in black walnut improvement has been slow and will probably continue to be so (11). The grafting of oaks (9, 26, 28, 29) and superior nut cultivars of black walnut (6, 8, 33) is the most successful method of asexual reproduction. If oak scion and stock do mend successfully, plant growth often remains stunted for several years (9). Additionally, interspecific oak graft combinations, in at least one instance, are plagued with delayed graft incompatability (1). Consequently, red oak and black walnut sawtimber stocks are normally seed propagated (15), but oaks, in particular, are extremely heterogeneous (9). Fast growing, well formed specimens may be seen growing alongside stunted, poorly formed trees (9). In addition, oak wilt disease, which is reportedly the greatest potential threat to the North American oak population, is capable of killing entire stands of oaks (20). Because of this threat, Durbin, a plant pathologist at the University of Minnesota, has isolated resistant seedlings by mass innoculative screening (14). If propagable, such strains might reduce loss from oak wilt disease when planted in future timber stands and tree lined boulevards.

Successful rooting of hard-to-root species following treatment with high concn of growth hormones has been shown (2, 9, 27). The rooting response of a species to growth hormones, or even optimum treatment level, can only be empirically ascertained (15). Upright English oak, Quercus robur L. 'Fastigiata' cuttings are rootable following a 20,000 ppm indolebutyric acid (IBA) treatment (9). Softwood Malus floribunda Van Houtte cuttings may be rooted at 10,000-30,000 ppm IBA; Malus 'Selkirk' and Malus sieboldii var. zumi 'Calocarpa' at 10,000 ppm IBA (2). Juvenile black walnut cuttings may be propagated following a 1 sec dip in a 5,000-8,000 ppm IBA solution (27).

Because of the desirability and difficulty in cloning outstanding timber, ornamental, nut, and disease resistant selections by cutting propagation, the purpose of this experiment was to observe the rootability of hardwood and softwood stem cuttings from mature red oak and black walnut trees following treatment with high concn of IBA.

II. LITERATURE REVIEW

Thimann and Delisle (32) reported as early as 1939 that three major groups of plants fail to root despite treatment with auxins: (i) the majority of the conifers, (ii) many forest hardwoods, and (iii) the apples and related rosaceous trees. Red oak and black walnut remain members of the second group despite 38 years of subsequent research.

A. Oak

Many oak species have been experimentally tested for rooting with supplemental auxin treatment (31). Thimann and Behnke (31) in their literature review of propagation to 1947 reported several early experiments with oaks. February cuttings from 4 year old red oak (*Quercus* sp.) trees had 22% rooting for non-treated control cuttings and 82% rooting for those treated 24 hr in a 100-200 ppm indoleacetic acid (IAA) solution (31). Cuttings from mature trees treated similarly did not respond. *Quercus rubra* winter cuttings (current season's growth only) from 3 to 4 year old trees rooted 10% without treatment and 18% with a 24 hr dip in 100-200 ppm IAA. Cuttings from trees over 60 years in age failed to root. In a similar test, cuttings were made with a basal section of the previous year's growth. Control cuttings responded with 22% rooting; those basally dipped for 24 hr in a 400 ppm IAA solution responded with 82% success (31).

Ward (36) rooted 1 year hardwood *Quercus rubra* shoots collected from pollarded hedge trees. Timing of cuttings (soon after leaf fall and before bud break) was found important for maximum rooting. Cuttings were dipped 5 sec in a water and alcohol (1:1) IBA solution. Although data were not given, the response from a 5,000 ppm treatment was reportedly preferential to a 2,500 ppm treatment.

Cuttings of Ness oak (Quercus virginiana X Q. lyrata) taken throughout the calender year and treated in 50-400 ppm auxin solution failed to root (10). Auxins of IAA, IBA, gamma indole-3-N-butyric acid, and commercially prepared Hormodin A were tested. Cuttings were dipped from 24-96 hr before sticking in the propagation medium.

Davis (4) has reported limited success in rooting succulent and hardened cuttings from pollarded 3 year old shrub live oak, Quercus tubinella Greene, trees. Indolebutyric acid did not prove helpful in root promotion, but instead, carefully maintained environmental conditions were most beneficial. Adequate light (1,600 ft-c), high humidity, intermittent mist, controlled air temperature (25° C), and controlled substrate temperature (30°) were most advantageous for rooting.

Hans Hess, a well known propagator, is reportedly rooting July cuttings of Quercus robur 'Fastigiata' at about 50% success by harvesting current season's growth and treating with a 2% (20,000 ppm) IBA in talc preparation (9).

Komissarov (18) has reported 65-80% rooting with July cuttings of Quercus robur from 3 year old trees treated in a 12-24 hr dip of 100 ppm IAA. Cuttings from 10 year old trees treated similarly resulted in 35% rooting.

Cuttings from Quercus agrifolia Nee trees over 75 years in age had 8% rooting following a quick dip in 8,000 ppm IBA (12). Maximum rooting (22.5%) occurred when similar cuttings were treated in a solution of 1,000 ppm dimethylsulfoxide (DMSO) and 8,000 ppm IBA.

Krahl-Urban has reported, following many years of empirical experimentation, that red oak varies clonally in rooting response (19). Additionally, an upper age limit of source trees was found to be about 20 years; cuttings from older trees consistently failed to root.

Significant clonal difference in rooting response has been found in oak populations. Deen, in taking cuttings from 12 ortets of Quercus ilex L., all 13 years in age, found response to vary from 0 to 40% (5). He suggested that clones should be selected for their ease of rooting.

Wyman (38) has air-layered 11 oak species with polythene film but without the use of growth hormones. No cutting rooted.

B. Black walnut

Because of the economic value of black walnut, black walnut propagation has been researched more than that of red oak. Consequently, more evidence has been gathered on the nature and limitation of their asexual root regenerative ability. McKay (23) and Farmer (6) have written review articles on their vegetative propagation.

Shreve (27) has rooted current season's growth forced from adventitious stem buds with 5,000-8,000 ppm IBA (1 sec dip). Growth originating from visible buds of 3-13 year old trees failed to root with the same treatment. Farmer (6), suggesting these buds as not being truly adventitious, has stated that non-visible supplemental axillary buds may possess the juvenility which is characteristic of true adventitious growth.

Farmer and Hall (7) found substantial clonal variation in the rooting response of juvenile black walnut cuttings. Stems which were etiolated, girdled, and pretreated with IBA in a lanolin paste before cutting responded better with 10,000 than 5,000 ppm IBA.

One year old black walnut cuttings grown through screen are reported to root (3). The system was developed so that as the stems thickened during the season they girdle themselves in the screen. The stems were then cut off at the girdle and stuck in the medium. Although successful, removing the girdled cutting also damaged the seedling by leaving little or no stem on the plant.

Paradox walnut hybrids (*Juglans hindsii* X *J. regia*) cuttings have been rooted with 73% and 60% response from 2 and 5 year old trees, respectively (22). Optimal success was obtained when cuttings were dipped (5 sec) in a 6,000-8,000 ppm IBA solution.

Serr (25) has propagated Paradox hybrids by trench layerage. Clonal variation contributed to differences in rooting response. Cuttings usually required 2 years before they were ready for orchard planting.

Serr (25) also experimented with hardwood cuttings of Paradox hybrids which were taken in December and January and soaked in a 24 hr solution of 225 ppm IBA. The cuttings were stuck in a wooden box with dampened peat moss and placed in an outdoor shed for cold dormancy treatment. The substrate was warmed by cable to 34°. Some cuttings rooted, but success rates were not reported.

Very limited success in black walnut stool propagation has been reported (16). However, other walnut species were found to be more amendable to this method of propagation.

III. MATERIALS AND METHODS

The experiment began with hardwood cuttings taken early December 1976, and continued with 4 successive trials. The last trial, consisting of softwood cuttings, was initiated in June 1977.

A. Cutting materials

Red oak cuttings were gathered from 6 sizable trees located, with the exception of one, on the Kansas State University campus (Table 1). Hardwood cuttings were taken on December 4, 1976, January 22, and March 5, 1977; softwood cuttings were obtained from the same trees on May 9, and June 18, 1977. With the use of a truck mounted ladder,

TABLE 1. Red oak cutting material; source and tree size.

Clone	Tree location	Tree diam (cm) (61 cm from ground)	Height (m)[1]
Tree No. 1	KSU Campus	32	10
Tree No. 2	KSU Campus	38	13
Tree No. 3	KSU Campus	37	14
Tree No. 4	KSU Campus	41	15
Tree No. 5	KSU Campus	36	12
Tree No. 6	Manhattan City Park	34	10

[1]measured by a Blume-Leiss altimeter

terminal cuttings were obtained from the lower one-half of the tree crowns. Water sprouts were avoided, and instead, typical stems were selected.

Cuttings from 3 clones of black walnut (Linn Co. No. 1, Leavenworth No. 1, and Indiana 55) were harvested from Rocky Ford Farm, Manhattan, and State Forestry Seed Orchard, Milford Reservoir, Junction City, Kansas. The walnut cuttings were obtained from many trees, all grafted, but varying in height from approx 3-4 m. On December 1, 1976, January 17, and March 6, 1977, hardwood cuttings were taken. Softwood cuttings were later obtained on May 12, and June 17, 1977.

Current season's growth was used exclusively for both red oak and black walnut cuttings. However, because of the softness of new growth for the May 9 cuttings, an additional red oak cutting trial was conducted in which cuttings had a basal 3-8 cm section of the previous year's growth. Red oak and black walnut cuttings were collected, moistened, and stored in plastic bags at 2^{o} until used.

B. Treatment

One to 2 days later, after all cuttings had been taken, they were treated and stuck. Cutting length varied from 10-18 cm depending on the growth rate of the source trees, but the length of the red oak cuttings were uniform for that tree source throughout the various treatments. Prior to treatment, cuttings were recut basally and trimmed to remove excessive foliage. Both sides of the basal ends were wounded using a razor blade tool similar to that described by Wells (37). The cutter is made of 3 single-edged razor blades bonded (epoxy) together alongside the protective edges. When used the blades make 3 cuts approx 1 mm apart. The stems were wounded by holding the blades diagonally across the stem and pressing down into the tissues. Subsequent to the first trial, the technique was modified by very slightly twisting the blades as the cuts were made, thus insuring an opened wound.

The study was restricted to examining the rooting influence of IBA in solutions at 10,000, 20,000, and 30,000 ppm. A stock solution was prepared by dissolving elemental analysis 3-indolebutyric acid (98% pure, Aldrich Chemical Co., Inc., Milwaukee, Wisconsin) into 95% ethyl alcohol. Portions of the stock solution were further diluted for 10,000 and 20,000 ppm treatment solutions. Control solution was 95% ethyl alcohol and contained no IBA.

C. Propagation facilities and management

After wounding, cuttings were dipped (5 sec) into IBA treatment solutions. The cuttings for each individual replication were prepared, wounded, and treated before beginning another treatment batch. After dipping, stems were allowed to dry 1-2 minutes before sticking into the medium.

Following treatment, cuttings were stuck in containers and moved to the propagation bench. Tinus root containers were used throughout the experiment. The containers are molded plastic sheets that form, when folded together and bound, 4 individual cells each measuring 4½ X 5 X 19 cm. Since the cells are open at the bottom, cut pieces of aluminum window screen were inserted. A course medium (Zonolite 100% vermiculite attic insulation, W. R. Grace and Co.) was used to encourage free movement of oxygen into the substrate.

Containers were supported on a wire mesh bench. A heating cable maintained a substrate temperature of 22-24°. Intermittent mist, applied 12-18 sec per 6 min from 7:30 AM to 8:30 PM and from 12 midnight to 1 AM, kept the foliage turgid. After sticking, cuttings were drenched with benomyl fungicide (1 tablespoon 50WP benomyl fungicide/ 2 gallons water). Additional drenches were applied every 7-10 days for the duration of the experiment.

To ascertain the effectiveness of high concentrations of IBA in root promotion, a simple test was made to study the rootability of juvenile oak cuttings. Because of its availability, juvenile growth originating from non-visible buds was forced from northern pin oak, Quercus ellipsoidalis E. J. Hill, stock. The trees were container grown, 3 year old trees in which the top growth had been cut back to within 2 inches of the stem collar. Cuttings were harvested, treated, and stuck on June 22, 1977, after terminal buds had formed, and stems had become semi-lignified. Procedures and treatments were identical to the other trials. Results were taken July 29, 1977.

D. Data collection

The following statistical design was used throughout the trials:

red oak: 10 cuttings/replication X 1 replication/clone X
5 clones X 4 treatments = 200 cuttings/trial.

black walnut: 6 cuttings/replication X 3 replications X
4 treatments X 2 clones = 144 cuttings/trial.

The northern pin oak cutting trial consisted of the same 4 treatments. One replication of 10 cuttings per treatment was made. The trial was not repeated.

Because of the poor response of red oak and black walnut, cuttings that rooted were recorded as such. No other data were collected. In the juvenile northern pin oak cutting trial, data were recorded for (1) number of roots per cutting, and (2) length of the 5 longest roots.

IV. RESULTS

All hardwood cuttings taken from mature red oak and black walnut trees failed to regenerate roots when treated with 0, 10,000, 20,000, or 30,000 ppm IBA. Generally, softwood cuttings cut from the same trees also failed to

TABLE 2. Rooting response of mature red oak cuttings to cutting dates, cutting types, and IBA treatments; Tree No. 1.

Cutting type	Dates		IBA (ppm)	Number of cuttings	
	Stuck	Examined		Stuck	Rooted
Dormant Hardwood	12-5-76	5-9-77	0 (control)	10	0
			10,000	10	0
			20,000	10	0
			30,000	10	0
Dormant Hardwood	1-23-77	6-20-77	0 (control)	10	0
			10,000	10	0
			20,000	10	0
			30,000	10	0
Dormant Hardwood	3-8-77	9-3-77	0 (control)	10	0
			10,000	10	0
			20,000	10	0
			30,000	10	0
Softwood[1]	5-10-77	9-3-77	0 (control)	10	0
			10,000	10	0
			20,000	10	0
			30,000	10	0
Softwood	5-10-77	9-3-77	0 (control)	10	0
			10,000	10	1
			20,000	10	2
			30,000	10	1
Softwood	6-18-77	9-3-77	0 (control)	10	0
			10,000	10	0
			20,000	10	0
			30,000	10	0

[1]cuttings included a 3-8 cm basal section of previous year's growth

TABLE 3. Rooting response of mature red oak cuttings to cutting dates, cutting types, and IBA treatments; Tree No. 3.

Cutting type	Dates		IBA	Number of cuttings	
	Stuck	Examined	(ppm)	Stuck	Rooted
Dormant Hardwood	12-5-77	5-9-77	0 (control)	10	0
			10,000	10	0
			20,000	10	0
			30,000	10	0
Dormant Hardwood	1-23-77	6-20-77	0 (control)	10	0
			10,000	10	0
			20,000	10	0
			30,000	10	0
Dormant Hardwood	3-8-77	9-3-77	0 (control)	10	0
			10,000	10	0
			20,000	10	0
			30,000	10	0
Softwood	5-10-77	9-3-77	0 (control)	10	0
			10,000	10	0
			20,000	10	0
			30,000	10	1
Softwood	6-18-77	9-3-77	0 (control)	10	0
			10,000	10	0
			20,000	10	0
			30,000	10	0

TABLE 4. Rooting response of juvenile northern pin oak cuttings to IBA treatments.

IBA (ppm)	Cuttings treated	Cuttings rooted	No. roots/cutting	Length of 5 longest roots/cutting (mm)
0 (control)	10	2	2	53, 101
			7	140, 104, 145, 60, 57
10,000	10	8	29	74, 60, 81, 63, 59
			39	84, 170, 120, 151, 104
			6	109, 116, 104, 118, 125
			19	148, 86, 85, 51, 49
			24	118, 116, 139, 124, 76
			14	148, 152, 165, 146, 88
			17	71, 150, 88, 96, 100
			17	95, 118, 128, 116, 101
20,000	10	7	1	12
			4	65, 68, 39, 53
			14	72, 132, 124, 91, 85
			26	80, 41, 40, 36, 39
			35	120, 59, 61, 63, 51
			2	78, 42
			11	29, 22, 20, 19, 11
30,000	10	6	3	73, 121, 41
			19	70, 63, 43, 38, 37
			7	24, 30, 12, 5, 4
			8	18, 19, 20, 17, 27
			10	39, 47, 55, 51, 47
			16	59, 47, 41, 30, 26

root. No black walnut cuttings rooted. Of 5 red oak cuttings that rooted, 4 were from tree 1; and all were in the first softwood cutting trial (Table 2). The fifth rooted cutting, from tree 3, responded at 30,000 ppm and was also cut in the first softwood cutting trial (Table 3). All red oak cuttings with a basal section of the previous year's growth also failed to root.

Data from table 4 show that juvenile northern pin oak cuttings treated with 10,000 ppm rooted in greater number than those treated with 0, 20,000, or 30,000 ppm IBA. There is variation in the number of roots per cutting within all treatment levels. For example, with 10,000 ppm of IBA the number of roots vary from 6 to 39; and with 20,000 ppm they vary from 1 to 35.

The data were counts and therefore not from normal populations; thus, the Kruskal-Wallis non-parametric analogue of a one-way ANOVA was used. This test is based on ranks of the data and makes no assumptions about their statistical distribution. The result from this test was essentially a chi-square of 5.94 (with 3 degrees of freedom) which is only at the 12% level of significance. Consequently, there is no difference in root number per cutting among the 4 treatments.

The 5 longest roots per cutting, when present, were interpreted by an analysis of variance test. The data were computed by a Hasp program for unequal numbers. Statistically, there was significant variation among treatments and among plants within the same treatments. A graphic description of mean root lengths is presented in fig 1. Significance levels among treatments are shown in table 5.

V. DISCUSSION

IBA, used in concn of 10,000, 20,000, or 30,000 ppm as a 5 sec basal dip, failed to induce root regeneration in hardwood and softwood cuttings taken from mature red oak and black walnut trees. Brown and Dirr (2) and others (9, 36) have empirically shown that many heretofore hard-to-root species may be rooted if treated with concn of IBA that were once considered excessive. This study indicates, however, that red oak and black walnut rooting is not promoted by such treatments.

Four of the 5 rooted red oak cuttings originated from tree designated number 1. Clonal variation may have influenced its success since researchers (5, 13) have found similar responses in other genera. Greenwood et al. (13), having found no significant difference of endogenous auxin content in easy- or hard-to-root sugar maple, *Acer saccharum* Marsh., ortets, believe unidentified factors may control rooting. However, tree age may also have affected rooting. Tree number 1, one of the 2 smallest source trees used, may not have totally passed from juvenility into maturity. Why juvenile growth roots more readily than mature wood has not

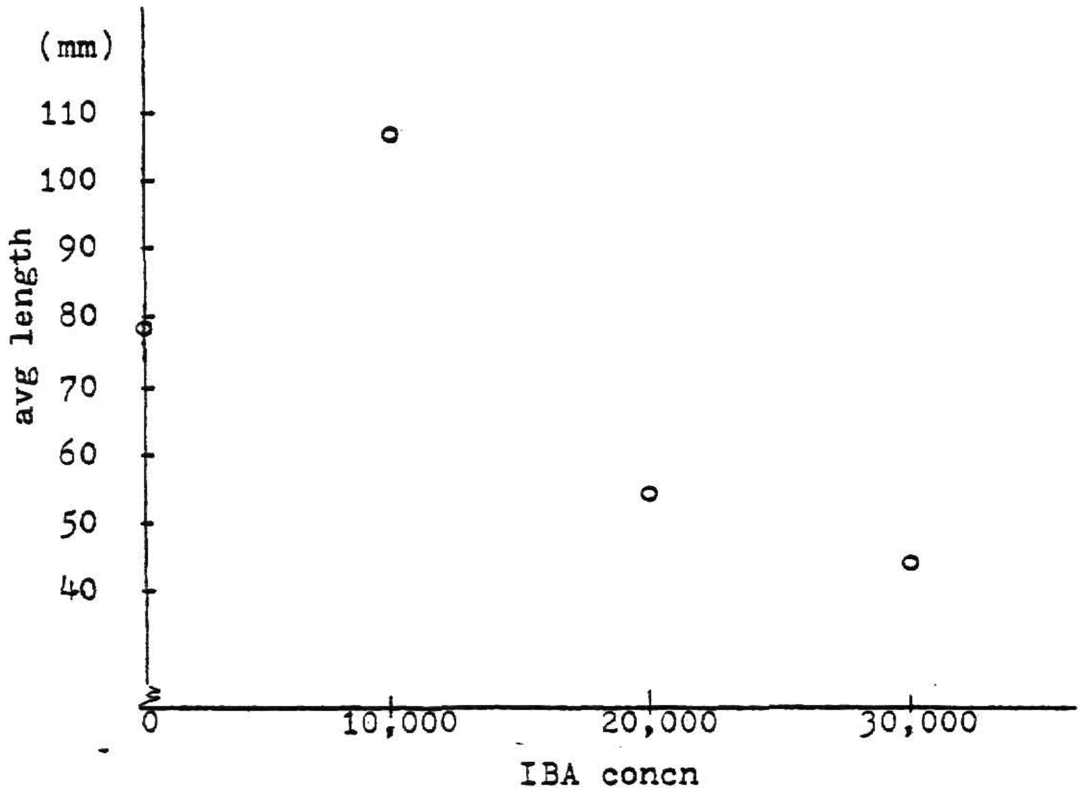

FIG 1. Graphic description of IBA influence on mean root length of juvenile cuttings of northern pin oak treated with 4 concn of IBA.

TABLE 5. Arrayed mean root lengths of juvenile cuttings of northern pin oak when treated with 4 concn of IBA.

Treatment	Mean length (mm)
10,000 ppm	107.30
	ns
0 ppm (control)	89.10
	ns
20,000 ppm	52.46
	ns
30,000 ppm	42.02

Brackets: 0 ppm (control) vs 30,000 ppm: +; 10,000 ppm vs 20,000 ppm: **; 10,000 ppm vs 30,000 ppm: **

ns = non-significant difference ($p > .10$);
+ and ** significant at the 10% and 1% level, respectively

been adequately explained (21). Loss or change of endogenous biochemical substances or change in apical meristem has been suggested (21). Krahl-Urban (19) has reported that red oak trees may produce some rootable cutting wood until approx 20 years of age.

All 5 rooted cuttings were harvested for the first softwood cutting trial which was initiated about 2 weeks after terminal buds had set and colored light brown. It is possible that greater rooting response may be obtained during a very limited time span, but probably not exceeding the time period in which the softwood cuttings were taken in this study. Stem cuttings of sugar maple have been found to root during a 2 week period just as growth reaches full size (13).

Hardwood black walnut cuttings failed to root despite heavy callus growth. Bud inhibition, a toxic response from excessively strong treatment concn, did not occur. During longer spring days, hardwood cuttings leafed out, although the leaves subsequently died and dropped off before expanding. All cuttings eventually died; but, under mist, many remained alive for several months.

Leafy softwood cuttings failed to root. Most cuttings although lasting lasting up to 2 weeks, prematurely succumbed to extreme ($>38^{\circ}$) greenhouse temperatures. Shreve (26) found that, with IBA treatments up to 10,000 ppm, all black walnut cuttings originating from growth of visible buds failed to root. He reported that only growth originating from adventitious buds in which the pith had not differentiated into plates would root. Because of the premature death of cuttings in this trial, it is not clear whether succulent cuttings (pith undifferentiated) taken from mature trees would root if treated at higher concn than those used by Shreve (26).

In the smaller trial of juvenile growth of northern pin oak, IBA effected an increase in number of cuttings rooted. Eight of 10 cuttings treated in 10,000 ppm rooted, whereas only 2 of 10 cuttings not treated with IBA rooted. Seven and 6 cuttings were rooted with 20,000 and 30,000 ppm IBA, respectively. Data from the study suggest that optimum rooting occured at 10,000 ppm; rooting response decreased at lower and higher concn. In all treatments there was considerable variation in the number of roots produced per cutting, but despite this difference, no statistical significance in this variation was found among treatments. In this regard, if a cutting initiated roots than IBA concn did not seem to influence actual root numbers formed.

An examination of fig 1 suggest little difference in mean root length of cuttings rooted in either 0 or 10,000 ppm. There is a decrease in mean root length in cuttings treated with 10,000 and 20,000 ppm. Thus, it appears possible that an optimum auxin dosage (maximum percent rooting and mean root length) might actually exist between 5,000 and 10,000 ppm. This is in accord with Ward (36) who found that cuttings from "hedge" grown red oak root better at 5,000 than at 2,000 ppm IBA.

VI. CONCLUSIONS AND SUMMARY

While some studies have indicated that high concn of IBA may induce rooting in difficult-to-root species, this study has shown that IBA, in concn of 0, 10,000, 20,000, and 30,000 ppm applied as a 5 sec basal dip, fails to promote rooting of mature red oak and black walnut cuttings. Three trials of hardwood cuttings were wounded and treated in December 1976, January, and March 1977, and placed under mist. Longer spring days induced many black walnut and red oak cuttings to leaf out, but all leaves failed to expand and subsequently dropped off. No hardwood cuttings of either species rooted.

Leafy softwood cuttings were later taken from the same red oak trees and from the same cultivars of black walnut. The first trial of red oak was made in early May after the trees' terminal buds had set and had begun to color brown. Throughout the study, only 5 cuttings rooted—all of which were taken for the first trial. One cutting was rooted with 10,000 ppm, 2 with 20,000, and 2 with 30,000 ppm IBA. Four of the 5 cuttings originated from one tree. No cuttings taken in the second trial (early June) rooted.

Softwood black walnut cuttings taken in both trials failed to root. Although not a problem with red oak, extreme greenhouse temperatures caused premature collapse and death of succulent black walnut foliage.

Propagation literature has frequently reported that juvenile growth roots more easily than mature growth. Furthermore, in difficult-to-root species, juvenile growth often is the only viable method of cutting propagation. In the smaller study of juvenile northern pin oak cuttings, a trial was conducted not to see if cuttings could be rooted, as it was believed that they could be; rather, what was the affect of techniques and IBA, as used with the mature stem cuttings, on the juvenile northern pin oak cuttings. A treatment concentration of 10,000 ppm effected maximum rooting with 0, 20,000, and 30,000 inducing less percent rooting. The number of roots formed on each cutting varied on plants within treatments, but the variation was consistent among all treatments. Mean root length was greater (but not statistically so) in a 10,000 than in a 0 ppm (control) treatment. Treatments of 20,000 and 30,000 ppm produced significantly shorter roots however. Results indicate that optimal auxin treatment may actually exist between 5,000 and 10,000 ppm.

It can thus be concluded that IBA in concn of 0, 10,000, 20,000, and 30,000 ppm does not promote rooting of mature red oak and black walnut cuttings. The use of juvenile wood remains the most substantial method of cutting propagation.

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ROOTING STUDY OF MATURE RED OAK AND BLACK WALNUT STEM CUTTINGS TREATED WITH HIGH CONCENTRATIONS OF IBA

by

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Hardwood and softwood cuttings from mature red oak, *Quercus rubra* L., and black walnut, *Juglans nigra* L., trees failed to root when treated with 0, 10,000, 20,000, or 30,000 ppm IBA (5 sec basal dip). Of 1,820 cuttings treated from December 1976, to June 1977, only 5 red oak cuttings rooted—4 of which were from one tree. No black walnut cuttings rooted. In a smaller trial, juvenile stem growth originating from non-visible buds of northern pin oak, *Quercus ellipsoidalis* E. J. Hill, were treated at the same concn. In this study, IBA effected maximum rooting percentage following a 10,000 ppm treatment; 0, 20,000, and 30,000 ppm effected less rooting. The data suggest that an optimal IBA dosage may actually exist between 0 and 10,000 ppm. However, in cuttings that rooted, there was no significant difference in number of roots per cutting or in their root length between control cuttings and those treated with 10,000 ppm IBA. Higher concn treatments caused reduced root length.