HORMONE ROOT-SOAK CAN INCREASE INITIAL GROWTH OF PLANTED HARDWOOD STOCK[1]

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Root soaking hardwood stock in certain IAA-kinetin-GA solutions before planting greatly increased root regeneration and early growth.

Plant growth hormones appear to control most developmental processes in plants. Three important classes of hormones are auxins, cytokinins, and gibberellins. Certain compounds of each hormone class are commercially available and can be externally applied to plants to alter their growth.

Our principal interest was to see if early growth of planted nursery stock could be improved by presoaking roots of seedlings in various hormone solutions. Studies were carried out in both greenhouse and field.

Materials and Methods

Greenhouse Studies

Three plant hormones, indoleacetic acid (IAA), kinetin, and gibberellic acid (GA_3, hereafter referred to only as GA), as well as catechol (an auxin synergist) and sucrose were applied via root-soak solutions to 1-0 nursery stock lifted in April, 1978. Tree species were northern red oak (*Quercus rubra* L.), white ash (*Fraxinus americana* L.), and yellow-poplar (*Liriodendron tulipifera* L.). The red oak stock was grown at Wooster from locally collected seed; white ash and yellow-poplar stock were obtained from Green Springs and Zanesville State Nurseries, respectively.

In the first greenhouse study, northern red oak taproots were cut at 15 centimeters and laterals trimmed off close to taproots. Groups of 10 trees were placed in beakers with the bottom 5 centimeters of taproots immersed in one of several hormone solutions. Each solution was a mixture of three hormones with each hormone at one of three concentrations (IAA at 0.1, 100, or 200 milligrams per liter (mg/l); kinetin at 0.01, 1, or 10 mg/l; and GA at 25, 250, or 500 mg/l) for a total of 27 different hormone treatments.

In the second greenhouse study, 10-tree groups of red oak were treated with root-soak solutions containing three compounds with each compound at one of three concentrations (IAA at 1, 100, or 200 mg/l; catechol at 50, 150, or 300 mg/l; sucrose at 5, 15, or 30 grams per liter (g/l) for 27 treatment combinations.

In the third greenhouse study, white ash and yellow-poplar trees were prepared as was the previously described red oak except that 1 to 4 inches of terminal stems of yellow-poplar were pruned off because of a fungal infection. Roots of each species were soaked in IAA-kinetin mixtures (IAA at 0, 10, 100 or 200 mg/l; kinetin at 0, 0.01, 0.1 or 1 mg/l) for 16 treatment combinations, or in GA alone (GA at 25, 250, or 500 mg/l) for three additional treatments.

In all studies a few drops of Tween 20, a wetting agent, were added to each solution. Trees were then soaked for 20 hours, planted in coarse vermiculite with two trees per 1-quart (946 ml) milk carton, and placed in a greenhouse under natural light. After 4 weeks, trees were harvested and amounts of new stems, leaves, and roots determined. Green weights of trees at time of planting were used as a covariate in statistical analysis. The experimental design was a randomized complete block, and data were subjected to analysis of covariance.

Field Plot Studies

Northern red oak seedlings were prepared as previously described except that taproots were pruned at 20 centimeters. Roots were soaked in IAA-kinetin mixtures (IAA at 0,100, or 200 mg/l; kinetin at 0, 0.1, or 1 mg/l) for nine treatment combinations and GA alone (at 25, 250, and 500 mg/l) for three additional treatments. Procedures for root-soaking were similar to those described above.

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Trees were outplanted on two old field sites at the Ohio Agricultural Research and Development Center. Herbaceous competition was controlled by chemical sprays and mowing. After 4 months, trees were harvested and amounts of new stems, leaves, total root dry weight, and total nonstructural carbohydrate (TNC) of roots (*12*) were determined. The statistical design was randomized complete blocks.

Table 1.—*Mean number and dry weight of new, regenerated roots of northern red oak, white ash, and yellow-poplar root-soaked for 20 hours in various IAA solutions.*

	IAA level (mg/1)				
Regenerated roots	0	0.1	10	100	200
Red oak[1 2]					
Number	—	2[a]	—	6[b]	7[b]
Dry weight, mg	—	4[a]	—	17[b]	18[b]
White ash[1]					
Number	19[a]	—	20[a]	31[b]	36[b]
Dry weight, mg	55[a]	—	57[a]	58[a]	86[b]
Yellow-poplar[1]					
Number	9[a]	—	12[ab]	14[b]	14[b]
Dry weight, mg	19[a]	—	27[ab]	26[ab]	32[b]

[1]Within each species, means not followed by a common letter differ at 0.05 level, Duncan's New Multiple Range Test.
[2]Each IAA solution for red oak also contained 0.01 mg/1 kinetin.

Results and Discussion

Results presented here are summaries of these studies, and only the most important main effects and interactions are discussed. A complete set of data will be sent upon request.

Greenhouse Studies

Root regeneration of trees was greatly increased by certain IAA treatments. All species showed increased numbers of new roots when treated with IAA at 100 or 200 mg/l (table 1). Dry weight of new roots was also increased at 200 mg/l of IAA. Stimulation of root growth by use of exogenous auxins has been reported by other researchers (*1, 3, 4*).

The IAA stimulation of root regeneration of red oak was completely nullified at high kinetin levels. For example, at constant 200 mg/l of IAA, the number of new roots decreased from seven to four to none as kinetin levels increased from 0.01 to 1 to 10 mg/l, respectively. In the third greenhouse study, the number of new roots decreased 16 percent as kinetin levels increased from 0.01 to 10 mg/l.

There were other IAA-kinetin effects. Red oak trees treated with low IAA-high kinetin had the longest stems (16.1 centimeters), while trees treated with high IAA-high kinetin had the shortest stems (10.5 centimeters) (table 2). Kinetin appears to increase IAA effects to supraoptimal levels, an interaction effect also noted in peas (*5*).

High GA levels resulted in increased stem lengths in red oak and white ash and increased leaf numbers in red oak (table 3). Similar GA effects were observed on newly germinated red oak and white oak seedlings (*8*) and on other woody plants (*2, 6, 11*).

An equally important GA effect, from the standpoint of seedling survival, was decreased root dry weight of red oak (table 3). Similar results were reported for yellow birch (*9*) and cottonwood and silver maple (*10*). In direct contrast to these results, however, root dry weight of white ash treated with GA was 2.4 to 2.8 times that of control trees (table 3). Further study of GA effects is warranted.

Another contrasting GA effect was that high levels of GA increased leaf numbers of red

Table 2.—*Mean new stem growth in centimeters of northern red oak seedlings root-soaked 20 hours in various IAA-kinetin solutions*

Kinetin level (mg/l)	IAA level (mg/l)			
	0.1	100	200	Kinetin mean
	cm[1]			
0.01	12.5[ab]	12.0[ab]	14.2[bc]	12.9
1	11.5[ab]	11.3[ab]	10.8[a]	11.2
10	16.1[c]	12.8[ab]	10.5[a]	13.2
IAA mean	13.4	12.0	11.8	

[1]Interaction means not followed by a similar letter differ at 0.05 level, Duncan's New Multiple Range Test.

Table 3.—*Growth of northern red oak, white ash, and yellow-poplar seedlings root-soaked 20 hours in various GA solutions*

	GA level (mg/1)			
	0	25	250	500
Red oak[1 2]				
New stems, cm	—	8.9[a]	13.7[b]	14.6[b]
Leaves, number	—	7.4[a]	9.1[b]	9.6[b]
Leaves, dry weight, mg	—	271[a]	170[b]	165[b]
New roots, dry weight, mg	—	8.0[a]	4.6[b]	4.8[b]
White ash[1 3]				
New stems, cm	1.4[a]	2.7[ab]	3.2[ab]	5.1[b]
New roots, dry weight, mg	40[a]	95 [b]	78 [ab]	114[b]
Yellow-poplar[1 3]				
Leaves, number	7.8[a]	8.1[a]	4.4 [b]	5.5[ab]
Leaves, dry weight, g	2.2[a]	1.4 [ab]	1.0 [b]	1.2[b]

[1]Within each species, means not followed by a common letter differed at 0.05 level, Duncan's New Multiple Range Test.
[2]At each GA level, IAA and kinetin levels combined, greenhouse study 1.
[3]Greenhouse study 3.

oak trees, but decreased leaf numbers of yellow-poplar trees (table 3). Total dry weight of leaves of both species was decreased at high GA levels, however. GA had little effect on elongation of yellow-poplar stems, perhaps because these trees had been top pruned before planting.

Addition of catechol and sucrose to various IAA solutions had small effect on growth of red oak seedlings.

Field Plot Studies

Northern red oak planted at two field sites were seriously affected by an unusually long 4-week drought that began just after planting in early May. Trees that developed early, vigorous shoot growth suffered considerable dieback late in the drought period.

Seedling growth at similar hormone treatments often differed between the two sites, even though the study areas were located less than one-half mile apart on similar types of soil. Periodic soil moisture measurements (psychrometer method) were similar at the two sites. The lowest soil-water potentials at a 12.5 centimeter depth was -12.4 bars on both sites on May 19.

At the first site, kinetin-treated trees grew better than controls; while at the second site kinetin-treated trees grew poorer than

Table 4.—*Growth and root carbohydrate content of northern red oak seedlings 4 months after planting on two old field sites. Seedlings root-soaked in indicated hormone solutions for 20 hours prior to planting.*

		Hormone treatment[1]			
	Site	Control	100 mg/1 IAA+ 0.1 mg/1 Kinetin	1 mg/1 Kinetin	500 mg/1 GA
Leaves, dry weight, g	1	1.37	2.29*	0.86	0.15*
	2	0.75	3.36*	2.03*	0.15*
New stems, cm	1	8.37	13.72*	5.42*	6.23
	2	7.03	18.89*	11.70	7.78
Total stems, dry weight, g	1	1.54	1.67	1.30	1.09*
	2	1.38	1.83*	1.60	0.97
Root, dry weight, g	1	3.44	4.14	2.64	2.48*
	2	2.52	3.18*	3.46	1.79*
Root TNC, %[2]	1	21.2	25.5	23.9	13.7*
	2	21.1	16.9	20.6	11.4*

[1]Means followed by * indicate difference from control at 0.05 level, t-test.
[2]Total nonstructural carbohydrate in percent of root dry weight.

controls (table 4). At both locations, however, greatest growth was attained by trees treated with 100 mg/l of IAA plus 0.1 mg/1 of kinetin.

Although data are not shown due to space limitations, trees treated with only IAA at either 100 or *200* mg/l grew as well as or better than controls with respect to all variables measured at harvest. This was true in spite of the fact that IAA trees appeared to suffer more damage than controls during the drought. As in the greenhouse studies, addition of kinetin to high-level IAA solutions resulted in decreased growth.

Red oak trees treated with GA at 500 mg/l grew poorly with regard to dry weights of leaves and roots (table 4). Also, the expected stimulation of stem elongation by GA was not apparent after 4 months. Earlier, however, GA trees appeared to have the longest stems of any treatment until the drought-induced dieback occurred. A previous study (*8*) demonstrated that GA treatments greatly reduced growth of northern red oak and white oak seedlings when soil water potentials were -4 bars or lower.

The TNC content of roots of trees at 500 mg/l of GA averaged only about 12 percent compared to 21 percent for controls (table 4). Previous research indicated that red oak stock with root TNC less than 15 percent grew poorly after planting (*7*). Growth of red oak seedlings treated with GA at 25 and 250 mg/l tended to be intermediate between that of control and GA at 500 mg/l.

The use of hormone treatments to stimulate early growth of planted trees is promising. A simple root-soak treatment with auxin greatly increased root regeneration. After 4 months in the field, total seedling weight of one auxin-kinetin treatment was 55 percent greater than that of untreated trees in spite of a severe drought.

Further work is needed before root soaking treatments can be recommended for general use. Lower-priced compounds such as naphthaleneacetic acid (NAA) should be tested. Also, perhaps even greater benefits are possible with hormone ratios different from those tested in this study. Optimum concentrations of hormones could be determined by studies designed to include orthogonal polynomials and regression techniques or response surface tests.

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