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Effect of Gibberellin on Height Growth of One-Year Old Seedlings of Loblolly Pine

M. Victor Bilan
and Arne K. Kemp

IN RECENT YEARS the use of gibberellin by plant scientists has created much excitement and speculation, particularly in agricultural and horticultural circles. Numerous experiments with various plants have been carried out studying the effect of gibberellin on height growth, initiation of flower buds, fruit setting and breaking dormancy.

Relatively little work has been done in studying the effect of gibberellin on growth of forest tree species. Some of the experiments with broadleaf species gave quite spectacular results, but the growth of conifers seemed to be but little affected by the gibberellin compounds. After reviewing studies dealing with the effect of gibberellin on coniferous tree species, Westing (7) concluded that the results were "generally negative."

Marth, Audia and Mitchell (4) reported that height growth of Japanese maple (*Acer palmatum* L.), sugar maple (*Acer saccharum* Marsh.), willow oak (*Quercus phellos* L.), yellow-poplar (*Liriodendron tulipifera* L.) and poplar hybrid (Populus, USDA Hybrid 247) was increased between 40 and 400 percent by treating the stems of seedlings with lanolin paste containing 0.125 to 1.0 percent of gibberellic acid. The same authors reported that less success was achieved by experimenting with seedlings of loblolly pine (*Pinus taeda* L.), Virginia pine (*Pinus virginiana* Mill.) and eastern white pine (*Pinus strobus* L.). Height growth of loblolly pines was not affected by either soaking the roots in the solution containing 1, 10, or 100 p.p.m. of

gibberellic acid, or by treating the stems with lanolin paste containing 0.25, 0.5 or 1.0 percent of gibberellic acid. Height growth of seedlings was increased 0 to 40 percent by spraying the shoots with a 400 p.p.m. solution of gibberellic acid. Height growth of established seedlings of Virginia pine was increased 28 to 68 percent by treating the stems with the paste of lanolin containing 0.25 percent of gibberellic acid, but newly transplanted seedlings failed to respond. Treatment of either new growth or old stems of eastern white pine with lanolin paste containing 0.25 to 1.0 percent of gibberellic acid failed to increase the growth.

By applying 1-percent solution of gibberellic acid in lanolin to the stems of eleven southern tree species, Nelson (5) was able to increase significantly the height growth of eastern cottonwood (*Populus deltoides* Bartr.), American sycamore (*Platanus occidentalis* L.), yellow-poplar (*Liriodendron tulipifera* L.), sweet gum (*Liquidambar styraciflua* L.), cherry bark oak (*Quercus falcata* var. *pagodaefolia* Ell.), willow oak (*Quercus phellos* L.) and southern red oak (*Quercus falcata* Michx.). Further, the above treatment failed to increase significantly the height growth of eastern white pine (*Pinus strobus* L.) and damaged the seedlings of Arizona cypress (*Cupressus arizonica* Greene).

According to Knight (2), repeated spraying of 1-0 old Engelmann spruce (*Picea engelmannii* Parry) seedlings and of first-year seedlings of western hemlock (*Tsuga heterophylla* [Raf.] Sarg.) with 10, 100, and 1,000 p.p.m. potassium gibberellate-water solution did not increase growth of either shoots or roots. Schoedle (6) reported that

growth of 1-0 old Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) was reduced by repeated spraying with 125, 250, and 500 p.p.m. solution of gibberellic acid.

Using concentrations of gibberellic acid of 10, 30, 60, 100 and 1,000 parts per million, Hooskaylo and Murphey (1) introduced the solutions directly into the trunk xylem of 9-year-old McKee hybrid poplar trees during the normal growing season. The treatments did not affect height or diameter growth of the trees.

The above review indicates that all of the experiments have been conducted using gibberellic acid concentrations of 1.0 percent or less. This report presents the analysis of height-growth data of one-year-old loblolly pine seedlings which were treated with gibberellic acid concentrations of 1.0, 2.0 and 3.0 percent.

Description of Study

Aqueous solutions of gibberellin¹ of 0, 1.0, 2.0 and 3.0 percent were prepared in 1000-cc glass cylinders. The gibberellin was first dissolved in alcohol using 15 mg of sodium bicarbonate and 2-cc of 95% ethyl alcohol for each gram of gibberellin. The obtained concentrate then was accordingly diluted with the tap water. Thirty grams of gibberellin powder were used to prepare 500 cc of each solution.

One-year old seedlings of loblolly pine (*Pinus taeda* L.) were lifted from the nursery bed one day before treatment, January 13, 1958. The experimental stock of 120 seedlings was randomly distributed over 24 bunches, five seedlings in each. Six bunches were treated in each cylinder containing solution;

¹Contributed by Chas. Pfizer & Co., Inc., Brooklyn 6, N. Y.

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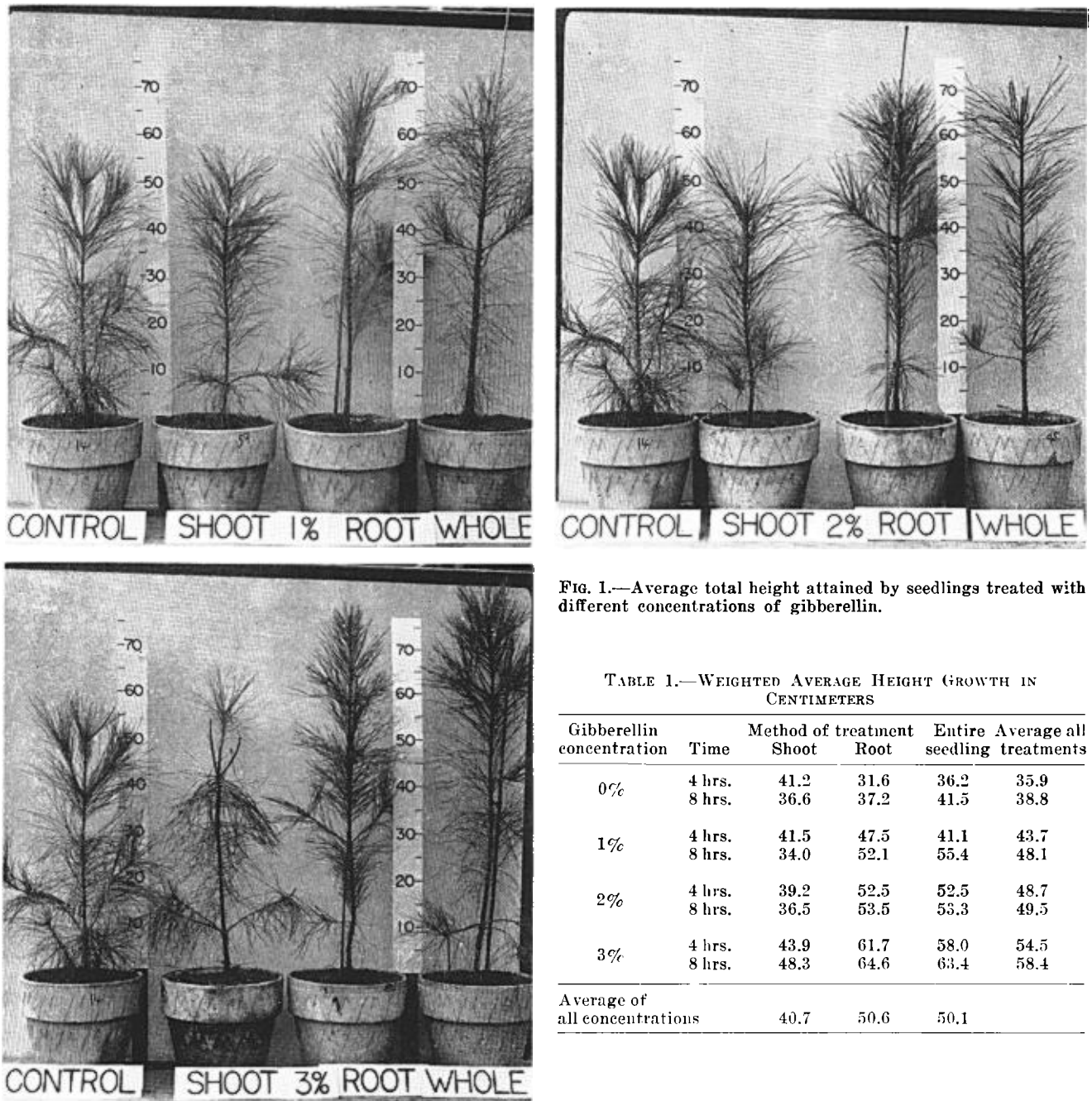


FIG. 1.—Average total height attained by seedlings treated with different concentrations of gibberellin.

TABLE 1.—WEIGHTED AVERAGE HEIGHT GROWTH IN CENTIMETERS

Gibberellin concentration	Time	Method of treatment		Entire Average all seedling treatments	
		Shoot	Root		
0%	4 hrs.	41.2	31.6	36.2	35.9
	8 hrs.	36.6	37.2	41.5	38.8
1%	4 hrs.	41.5	47.5	41.1	43.7
	8 hrs.	34.0	52.1	55.4	48.1
2%	4 hrs.	39.2	52.5	52.5	48.7
	8 hrs.	36.5	53.5	53.3	49.5
3%	4 hrs.	43.9	61.7	58.0	54.5
	8 hrs.	48.3	64.6	63.4	58.4
Average of all concentrations		40.7	50.6	50.1	

two bunches were submerged completely while only shoots or roots of the remaining four bunches were submerged in the solution. Half of the seedlings were treated for four hours, and the remaining half for eight hours. It is worthwhile to mention that an average of about 2 cc of solution was utilized by each treated seedling. The unutilized solutions were not tested to determine if the dipped seedlings had altered the original concentrations.

After treatment the seedlings were planted immediately in 10-inch clay pots filled with sandy-

loam top soil and placed in a heated greenhouse until the end of April after which they were placed outdoors.

Original height and weekly growth of individual seedlings were measured and recorded in centimeters. To preserve consistency all measurements were made from the top edge of the pots. The final measurements were taken on September 18, 1958. The difference between original height and the last measurement was considered as the growth caused by the im-

posed treatments. These data were analyzed statistically according to a split-plot method.

Various agencies caused death of 10 seedlings, but the mortality was distributed randomly and did not seem to be associated with any particular treatment. The loss was accounted for in the statistical analysis of data by introducing proper weights and by reducing correspondingly the degrees of freedom. The weighted average height growth of individual treatments is presented in Table 1.

Discussion

The average height growth of seedlings treated for eight hours was, in most cases, slightly higher than the height growth of seedlings treated only for four hours; however, the difference was not sufficient to be statistically significant.

Analysis of variance revealed that both the method of treatment and the concentration of gibberellin in solution were highly significant factors.

Treatment of the roots or of the entire seedlings stimulated height growth significantly more than did the treatment of the shoots alone (Fig. 1). On the other hand, no significant differences existed between the treatments of the roots and of the entire seedlings. The average height growth of shoot, root, and entirely-treated seedlings was 41 cm., 51 cm. and 50 cm. respectively.

Each of the three concentrations of gibberellin stimulated height growth of treated seedlings. The three-percent concentration was significantly better than the other two concentrations, but the two-percent solution was no more effective than the one-percent solution. The average height growth of seedlings treated in the solution of zero, one, two, and three-percent concentration of gibberellin was 37 cm., 46 cm., 49 cm. and 56 cm., respectively.

It appears that, at least during the dormant season, dipping of the roots of loblolly pine seedlings in the solution containing at least one percent of gibberellin stimulates the subsequent height growth more effectively than the dipping of the shoots.

As indicated in Table 2, shoots treated in one or two-percent solution of gibberellin did not respond with an accelerated rate of growth. Shoot-treatment in a three-percent gibberellin solution resulted in a significant increase in height growth, but the increase was considerably less than that of

TABLE 2.—AVERAGE HEIGHT GROWTH PER TREATMENT AND CONCENTRATION DISREGARDING THE DURATION OF TREATMENT

Concentration of gibberellin	Average height growth in centimeters				Average height growth as percentage of average for control (37.3)			
	Shoot	Root	Entire seedling	All treatments	Shoot	Root	Whole treatments	All
Control	38.6	34.7	38.9	37.3				100.0
1%	38.4	49.8	49.1	45.9	102.9	133.5	131.6	123.1
2%	38.1	53.0	52.9	49.1	102.1	142.1	141.8	131.6
3%	46.1	63.2	60.4	56.4	123.6	169.4	161.9	151.2

root-treated seedlings in a one-percent solution.

It is believed that the failure of the shoot treatment to cause increased height growth can be attributed to the vegetative condition and anatomical structure of the treated loblolly pines. In order to influence growth it appears logical to assume that gibberellin has to enter into the living cells or at least into the living tissue. Since shoots of treated seedlings were in a dormant condition, there was no young tissue exposed to the gibberellin. The well-protected buds and heavy epidermis of the mature needles evidently impeded the entrance of gibberellin into the living tissue.

The situation was quite different in the case of root treatment. The roots were actively growing and much of the un lignified tissue was exposed to the gibberellin solution. The absorption of water and probably gibberellin was enhanced also by the transpiring shoots being exposed to the room temperature.

In addition to height growth, gibberellin also produced some other morphological changes in the treated seedlings. As the concentration of gibberellin solution was increased, the number and length of the lateral branches decreased; the needles became lighter in color and tended to show a more pronounced alignment with the longitudinal axis of the stem.

Summary

One-year old seedlings of loblolly pine were treated with one, two, or three-percent aqueous solutions of gibberellin. Either roots,

or shoots, or entire seedlings were soaked in a solution for four or eight hours. No significant differences existed between height growth of four and eight-hour treated seedlings.

Each of the three used concentrations increased height growth of root or entirely-treated seedlings, the increase being proportional to the higher concentration of gibberellin in the solution.

The shoot-treated seedlings responded only to the highest concentration of gibberellin.

In addition to height growth, gibberellin produced also other morphological changes in the treated seedlings.

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