Timing important, research shows

Growth regulators stimulate ponderosa pine seedling development

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Effect of growth regulator treatment on development of ponderosa pine seedlings was examined in a greenhouse experiment. An auxin treatment containing 0.5 ppm indoleacetic acid and 0.05 indolebutyric acid used in combination with a shoot inhibitor produced superior root growth, but comparisons with other tests show that treatment timing and physiological condition of stock are important considerations.

Reforestation of ponderosa pine (Pinus ponderosa Laws) is often difficult. Shopmeyer (1940) found that seedling mortality reached as much as 45 percent in plantations in the northern Rockies; 80 percent mortality has been observed in the southwest (Price, 1963) . Stone (1967) determined that outplanted ponderosa pine seedlings must produce an average of 70 cm (27 inches) total root growth during the first month after planting for optimal survival rate under normal field conditions in California. This much growth is probably required on most ponderosa pine planting sites. Unfortunately, it is not uncommon to find outplanted stock producing little or no new root growth. This lack of adequate root development leads almost inevitably to death from drought injury.

Mortality of planted seedlings might be greatly reduced if a way were found to increase root proliferation and elongation and decrease growth of the transpiring surface. Treatment of seedlings with growth regulators offers one possibility. Although most efforts with growth regulators have failed, recent evidence (Van Lear, 1970) suggests that a combination of growth regulators may be the key.

Procedure

Our experiment involved planting treated and untreated 2-0 ponderosa pine seedlings individually in plastic lined fiberboard mailing tubes, 4 inches wide and 20 inches deep, and filled with a sand-soilsponge rock mixture. Seedlings were lifted from the nursery and planted in the tubes in March. It should be noted that these seedlings were about to break dormancy at the time. Roots were soaked in solutions containing varying concentrations of indoleacetic acid (IAA) and indolebutyric acid (IBA) (table 1). Both chemicals are considered to be growth stimulators. Following root treatment, the seedling tops were soaked in varying concentrations of maleic hydrazide (MH), a growth inhibitor (table 1). We thought that this combination would increase root growth while decreasing shoot growth.

Each treatment involved 20 seedlings arranged on greenhouse benches in a randomized complete block design containing 10 replications. Soil moisture within the tubes was maintained at field ca-

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TABLE 1.—*Effect of growth regulators on bud dormancy, shoot elongation, and new root initiation and elongation of 2-0 ponderosa pine seedlings.*

Treatment				Bud dormancy burst (percent)				Final	Average	Number of new roots		Average length
	IAA	IBA	MH	Weeks since planting				Bud Burst	elongation	under	over	of three longest
				1	2	3	4	Index[1]	shoot	1-cm	1-cm	roots
	ppm	*ppm*	*ppm*						*cm*			*cm*
A	10.0	1.00	10	33	61	66	72	1.6	2.3	172	70	20.3
B	10.0	1.00	50	53	68	79	79	2.5	1.8	198	78	24.4
C	10.0	1.00	100	37	47	53	63	1.9	2.4	102	54	13.6
D	1.0	0.10	10	20	60	75	75	2.3	2.5	140	60	15.0
E	1.0	0.10	50	30	45	65	75	2.1	2.1	175	75	23.3
F	1.0	0.10	100	33	67	67	75	2.3	1.8	108	51	20.4
G	0.5	0.05	10	45	65	85	90	2.9	2.6	153	69	22.8
H	0.5	0.05	50	70	90	95	100	3.7	3.2	192	107	27.7
I	0.5	0.05	100	25	80	85	90	2.8	2.5	209	87	24.6
J	200 ppm ETOH and 200 ppm diethylamine			45	70	70	85	2.7	2.4	105	55	22.2
K	Control			45	70	85	90	3.0	2.2	82	52	16.4

[1] Bud Burst Index = $\frac{(b_1 \times 4) + (b_2 \times 3) + (b_3 \times 2) + (b_4 \times 1)}{\text{total number of seedlings per treatment}}$ where b_1, b_2, b_3, and b_4 are the number of seedlings which broke bud dormancy during the first, second, third, and fourth weeks respectively.

pacity by watering on alternate days. "Gro Lux" light banks were utilized to maintain a 14-hour day length, and greenhouse temperatures ranged from 67°F. at night to 83°F. during the day (occasionally reaching 90[1]F.). Relative humidity ranged from 30 percent during the day to 80 percent at night. The experiment was completed after a 4-week period.

The number of seedlings which had broken bud dormancy (bud burst) was noted weekly and expressed as an index using the technique described by Lavender and Herman (1970) At the conclusion of each experiment, average shoot elongation per treatment was determined and root growth inspected. Roots were removed from the soil and the number of new roots, both under and over 1 cm, were counted, and the lengths of the three longest roots measured and averaged.

Results and Discussion

Although statistical significance could not be shown, table 1 data indicate that high concentrations of auxin (treatments A, B, C, D, E, and F), regardless of MH concentration used, tended to depress bud burst as compared to the control. Low concentrations of auxin (treatments G, H, and I) do not depress bud burst and may, in fact, increase it. Treatment effects were apparently short-lived, since the relationships were not as pronounced once the shoots started elongation. These results show that MH apparently is not particularly effective in suppressing bud burst and subsequent shoot elongation, as had been thought previously.

In general, all growth regulator treatments increased root growth and initiation when compared to the control, with the smallest effects noted in treatments C and F (table 1) . In fact, treatment C actually produced a slight decrease in average length of the three longest roots. Both treatments C and F utilized the highest rates of MH in conjunction with relatively high levels of IAA and IBA. Apparently these concentrations were too high for stimulation of root growth. Lower concentrations of MH resulted in greater root initiation and elongation (treatments A, B, D, and E), but regardless of MH concentration, the greatest and most consistent increase in root development occurred with the lowest auxin concentration tested (treatments G, H, and 1).

Whether or not benefits result from treatment of seedlings with plant growth substances may well depend on the physiological state at time of application. Our results were obtained on seedlings treated as they were about to break dormancy. In a second experiment, IAA, IBA, and MH treatments were applied to seedlings lifted from the nursery bed when 18 inches of snow covered the ground and the plants were still in a state of deep dormancy. Much less effect was noted in this instance. It appears that before growth regulators are applied to coniferous seedlings on an operational basis, considerably more research regarding optimum time for treatment will have to be done. In this regard, a particular problem is that the physiological condition of the stock varies from year to year on the same calendar date. Because of this, it will not be possible to specify an arbitrary date for treatment of seedlings grown at any particular nursery. The actual physiological status of the stock must be monitored.

Literature Cited

Lavender, D. P. and R. K. Hermann.
1970. Regulation of the growth potential of Douglas-fir seedlings during dormancy. New Phytol., 69:675-694.

Price, R.
1963. Annual Report. Rocky Mountain Forest and Range Experiment Station. USDA Forest Service. P. 22-23.

Shopmeyer, C. S.
1940. Survival in forest plantations in the Northern Rocky Mountain Region. Jour. of Forestry, 38:16-24.

Stone. E. C.
1967. A nursery - conditioned root growth response to the field environment. Proc. 14th Congr. Int. Union For. Res. Organ., *Munich* Pt. III, Sect. 22:248-264.

Van Lear, D., H. Loewenstein, and F. H. Pitkin.
1970. The influence of maleic hydrazide and certain auxins on growth and survival of Douglas fir seedlings. Forest, Wildlife and Range Experiment Station, Moscow, Idaho. Station Paper No. 6.