EFFECTS OF SEEDBED DENSITY AND NURSERY FERTILIZATION ON SURVIVAL AND GROWTH OF 3-0 WHITE PINE

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The Normal top-dressing with fertilizers during the second and third growing season was ineffective; lower seedbed density (15 trees per square foot) was highly effective in producing better stands. Cultivation of the planting site seems to offer large benefits in plantation establishment.

It is usually suggested that trees grown under conditions of "optimum" nutrient supply at the nursery grow best after outplanting (*2, 4, 13*).

Thinning seedbeds to low levels of density, as low as 10 trees per square foot, has usually given increased size and better balanced stock (lower top-root ratio) (*1, 3, 14*) with "carryover" benefits of improved survival and growth (*7, 10, 11, 12*). For white pine, Bunting (*6*), by thinning at the 1-0 stage, similarly obtained increases in dry weight and stem diameter. The increases were proportionate to density and were greater at densities below 15 trees per square foot.

To corroborate these observations and conclusions an experiment was begun in the spring of 1968 at Midhurst and Orono nurseries in southern Ontario to study the effectiveness of the nursery fertilization program as well as the effects of seedbed density on 3-0 white pine (*Pinus strobus* L.) shipping stock.

Materials and Methods

In this test the recommended fertilizer amounts, based on prior analyses of soil and seedling samples, were compared with a "control" (no fertilizer) and a "double" level. In addition, the seedbeds were thinned at the 1-0 stage (spring 1968) to two density standards, 15 and 30 trees per square foot. Effects were studied by measuring the nursery stock at the 3-0 stage, and by field planting tests, the results of which were available to the fifth year after planting.

In the layout of the experiment on the 1-0 beds at Midhurst and Orono there were five replications of a split-plot design; the main plots based on fertilizer treatment, the sub-plots based on seedbed density. At Midhurst the normal fertilizer for 1968 was 45 lbs of ammonium sulphate and 45 Ibs of potassium sulphate per acre, applied 4 times at approximate monthly intervals. In 1969, the rising 3-0 year, there were again four dressings of the same chemicals, the first two at 65 lbs per acre, the second two at 45 Ibs per acre. At Orono the normal fertilizer treatment consisted of three applications of ammonium sulphate at 100 Ibs per acre, and this was repeated in the 3-0 year, 1969.

In the spring of 1970 the 3-0 white pine was used to establish two field test plantations; one at the Midhurst Research Centre (60 miles north of Toronto) and the other in Oxford Township (30 miles south of Ottawa). The Midhurst planting plan was a fully randomized block design of the six fertilizer x density treatments from both nurseries, a total of 60 plots of 50 trees each. Planting, using the wedge method, was done April 29 to May 1. The soil was a sandy loam, cultivated by plowing in fall 1969, disking before planting in 1970, and harrowing in 1970 and 1971 to reduce competition from weeds and grasses. The Oxford planting used the same design, and the planting was done on April 30 and May 1. In this case, however, the planting, also using the wedge method, was in an old pasture field in the bottom of a plowed furrow, and there were no subsequent cultivation treatments. The soil here was sandy and moderately dry.

This report is based on the condition of the stock at shipping, and the fifth year survival and growth following outplanting. The analyses were by the analysis of variance, using angular transformation of survival, and plot averages for height and stock characteristics. Differences between treatments were compared by the Duncan range test.

Results and Discussion

Effects on Shipping Stock

The effects of the nursery fertilization treatments and seedbed density differences on

the stock at the time of shipping are summarized in table 1.

In the 2 years of growth, the fertilizers (ammonium sulphate and potassium sulphate at Midhurst, ammonium sulphate alone at Orono) at the rates applied had produced no significant effects on size and balance of the trees. Seedbed density, on the other hand, was a major factor, the 15-per-square-foot level producing larger (by ODW) and sturdier (lower top-root ratio) trees than the 30-per-square-foot density.

Therefore, on the basis of measurement of the nursery product of 3-0 white pine, the top-dressing fertilizers as used were largely wasted at both nurseries whereas seedbed densities to 15 trees per square foot were beneficial.

Effects on Planting Performance

The effects of the treatments on the survival and height of the trees at the end of 5 years after outplanting have been summarized in table 2. The fertilizers had no significant effect on performance of the trees in the Midhurst planting, and a detrimental effect on the performance of the trees in the Oxford planting. Thus, it appears that the normal and double fertilizer applications wasted both time and materials in the carryover effects to outplanting.

Table 1.—*Effects of fertilizer levels and seedbed density on 3-0 white pine in the nursery by nurseries and by treatment*

		Top Length	Root Length	Stem Diameter	Ovendry Weight	Toproot Weight
		(cm)	(cm)	(cm)	(g)	(ratio)
Midhurst						
	C	14.6	36.9b	0.39	4.31	2.70
	N	14.7	33.4a	0.41	4.63	3.03
	D	14.0	34.6a	0.40	4.50	2.62
		NS	**	NS	NS	NS
	15	14.0	37.3	0.41	4.72	2.49
	30	14.8	32.7	0.40	4.23	3.08
		NS	***	NS	**	**
Orono						
	C	13.5	34.7	0.46	5.36	3.17
	N	13.2	35.9	0.46	5.65	3.00
	D	13.8	31.4	0.48	5.84	3.39
		NS	NS	NS	NS	NS
	15	12.8	36.6	0.48	6.18	2.74
	30	14.2	31.4	0.45	5.06	3.63
		*	*	NS	**	**

Fertilizer Treatments
C (control) = no further application after 1-0
N (normal) = recommended level
D (double) = twice normal

Density
15 = 15 trees per ft^2
30 = 30 trees per ft^2

NS = not significant
* = significant at 5.0 percent level
** = significant at 1.0 percent level
*** = significant at 0.1 percent level
Items in columns not followed by same letter are significantly different at 5 percent level or better

Using aggregate height (survival percentage X average height) as a standard for comparison (*9*), the normal fertilizer practices at Midhurst and Orono reduced the stands by about 6.3 percent and 12.2 percent, respectively.

On the other hand, the effect of the lower seedbed density is significant in producing better height growth at both locations. The lower density from both nurseries also produced higher survival at both locations, although not significantly so.

Table 2.—*Effects of nursery fertilizer levels and seedbed densities on survival (percent) and average height (centimeters) at 5 years after planting for white pine*

		Oxford		Midhurst		Average Survival	Average Height	Aggregate Height
		Survival	Height	Survival	Height			
		(percent)	(cm)	(percent)	(cm)	(percent)	(cm)	(cm per acre)
Midhurst	C	86.6	61.4b	95.4	143.6	91.0	102.5	112,863
	N	80.6	55.4a	93.2	145.7	86.9	100.6	105,780
	D	77.6	55.9a	89.2	151.7	83.4	103.8	104,749
		NS	*	NS	NS			
	15	81.9	58.7	95.5	150.6	88.7	104.6	112,264
	30	81.3	56.6	89.7	143.3	85.5	100.0	103,455
		NS	*	NS	NS			
Orono	C	94.0b	70.6b	92.4	162.6	93.2	116.6	131,492
	N	79.0a	63.5ab	93.8	157.3	86.4	110.4	115,416
	D	90.6a	61.5a	94.4	154.0	92.5	107.8	120,655
		*	*	NS	NS			
	15	88.1	66.9	96.3	164.6	92.2	115.8	129,189
	30	86.9	63.8	90.8	150.9	88.8	107.4	115,399
		NS	NS	NS	**			
Between Nurseries								
Midhurst		81.6	57.7	92.6	147.1	87.1	102.4	107,920
Orono		87.9	65.4	93.5	157.9	90.7	111.6	122,478
		*	*	NS	**			

Fertilizer treatments
C (control) = no further application after 1-0
N (normal) = recommended level
D (double) = twice normal

Density
15 = 15 trees per ft^2
30 = 30 trees per ft^2

NS = not significant
* = significant at 5 percent level
** = significant at 1 percent level

Items in columns not followed by same letter are significantly different at 5 percent level

Comparing the plantations, again by aggregate height, the stock from 15-per-square-foot beds at Midhurst and Orono had 8.5 percent and 11.9 percent more aggregate height, respectively, than stock from 30-per-square-foot beds.

Influences of Planting Site

The differences between the height growth for the Oxford planting and the Midhurst planting are striking, the latter averaging 148 percent better. The Oxford site was considered more severe; it was drier, and as only furrowing was used before planting, there was more competition. The Midhurst site was cultivated before and after planting. Cultivation was

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probably the chief cause of the 173 percent greater aggregate height. A similar effect has been achieved from the cultivation of a white spruce stand where 166 percent greater aggregate height was obtained over the noncultivated controls (*8*).

On the Oxford site, more severe probably for both moisture and competition factors, the normal and double fertilized stock performed poorly (table 2). On the more suitable site at Midhurst, the differences in performance caused by fertilization were not significant. Thus, it may be speculated that overfertilization actually weakened the stock (*5*).

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