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"SUPER" SPRUCE SEEDLINGS CONTINUE SUPERIOR GROWTH FOR 18 YEARS

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ABSTRACT.—White spruce seedlings—20, 19, 18, and 17 inches tall—were selected among 2-2 transplants; controls from the same beds averaged 7.7 inches tall. After 18 years in the field, the selected seedlings continued to have a 30 percent height growth advantage over the controls. This note discusses how to incorporate super spruce seedlings into a tree breeding program.

KEY WORDS: *Picea glauca*, juvenile selection, tree improvement and breeding, seed production areas, vegetative reproduction.

White spruce (*Picea glauca* (Moench) Voss) seedlings selected on the basis of superior nursery growth maintained their growth advantage after 18 years of field testing. Nursery selection of super seedlings may be one way to make long-term breeding programs more efficient.

METHODS

In 1956, 696 white spruce seedlings were selected in 2-2 transplant beds of the Consolidated Paper Company's nursery east of Rhinelander in northeastern Wisconsin. The selected seedlings were grouped into four height classes: 17, 18, 19 and 20 inches (table 1). Controls were picked at random from seedlings next to the selected ones and averaged 7.7 inches tall. The seedlings were paired and planted in rows on the company's Experimental Forest east of Rhinelander. No statistical design other than the pairing was used. The site was not ideal for white spruce because it lacked uniformity in soil moisture and air drainage. Much of it was wet and frosty early in the growing season.

Tree heights were measured in 1961 and 1962 and frost injury scored in 1964. After 7 growing seasons in the field, the selected seedlings had maintained their superiority over the controls. (King *et al.* 1965).

Flushing of the buds was scored in May 1973 using six classes of bud development as described by Nienstaedt and King (1969). Total tree heights were measured later that fall.

RESULTS

By 1973, 84 percent of the seedlings had survived and 74 percent of the pairs were intact. There were no important differences in survival between the selected seedlings and the controls (table 1).

The selected seedlings continued to have a 30 percent height growth advantage over the controls on the average. This, according to the t-test on the pairs, is highly significant statistically, unlike the effect of seedling height class. The 7-year heights were highly correlated with 18-year heights with r values exceeding 0.8. Not only are the selected trees taller than the controls, but the frequency distribution of the two groups is normal (fig. 1). In the selected

N. C. ARCHIVES

Table 1.—*Survival and height growth of surviving seedling pairs at 18 years after field planting*

Class		Pairs planted	Pairs surviving	Seedlings surviving	Seedling survival	Height	S.D.	t[1]	Superiority
		Number	*Number*	*Number*	*Percent*	*Feet*			*Percent*
20	S	59	45	53	90	12.85	3.35	4.741	33.2
	C			50	85	9.65	3.39		
19	S	102	56	68	67	12.17	3.63	5.126	36.7
	C			77	75	8.90	3.03		
18	S	201	161	176	88	12.33	4.02	9.794	33.9
	C			182	91	9.21	3.17		
17	S	334	244	288	86	12.27	3.59	9.172	26.5
	C			280	84	9.70	3.19		
Combined	S	696	506	585	84	12.33	3.71	14.95	30.55
	C			589	85	9.45	3.21		

[1]t-test for heights.

population, 296 trees are 12 feet or smaller while 289 are taller than this mean height; in the control population, 489 trees are 12 feet or smaller and only 100 are taller.

Minor differences in the time of flushing were not significant and are not shown.

DISCUSSION

Reducing the age at which reliable phenotypic selections can be made will substantially reduce the cost and increase the effectiveness of forest tree improvement programs. Several options for incorporating juvenile selections into such programs are available depending on program objectives and funding.

If early production of improved planting stock is the objective, vegetative propagation of the selected seedlings may be the option to try. Such programs are now underway for Norway spruce in Germany (Kleinschmidt 1974, Kleinschmidt *et al.* 1973), Denmark (Roulund 1976, 1979) and elsewhere. In addition, mass production techniques for juvenile white spruce material are now being developed in Canada and the United States (Rauter 1974, Nienstaedt 1979, Armson *et al.* 1980). Using perfected rooting techniques and hedges to maintain rooting ability, about 200 selections should produce 300,000 to 500,000 plantable trees annually after 5-7 years (Nienstaedt 1979).

Incorporating the juvenile selections into multi-generation breeding programs will require testing as in our study. Control seedlings can be omitted from such tests if suitable land is scarce. The test site should be uniform and capable of producing good white spruce.

If early seed production is an objective and funding limited, developing the test planting into a seed production area (SPA) could be the best approach. The test in our study covers a little less that 1 acre with an original spacing of about 6 feet by 5 feet. Because SPA spacing should be about 20 feet by 20 feet, the test planting would need to be thinned to 104 trees in the 16 foot height class or taller: 97 select trees and seven control trees (fig. 1). A broad genetic base would be required from the beginning of the program; the selection and breeding strategy would depend on the populations available, the breeding zone and the agencies involved.

To assure full development of the crowns, thinning should begin as soon as flowering does—on most sites it could probably begin at about 12 years from seed and end at 20 years. By this approach, further genetic improvement could be achieved with repeated two-stage mass selection in the nursery and plantation representing advancing generations of the population.

If maximum yield improvement through a long-term intensive breeding program is the main goal and funding not a limiting factor, the approach

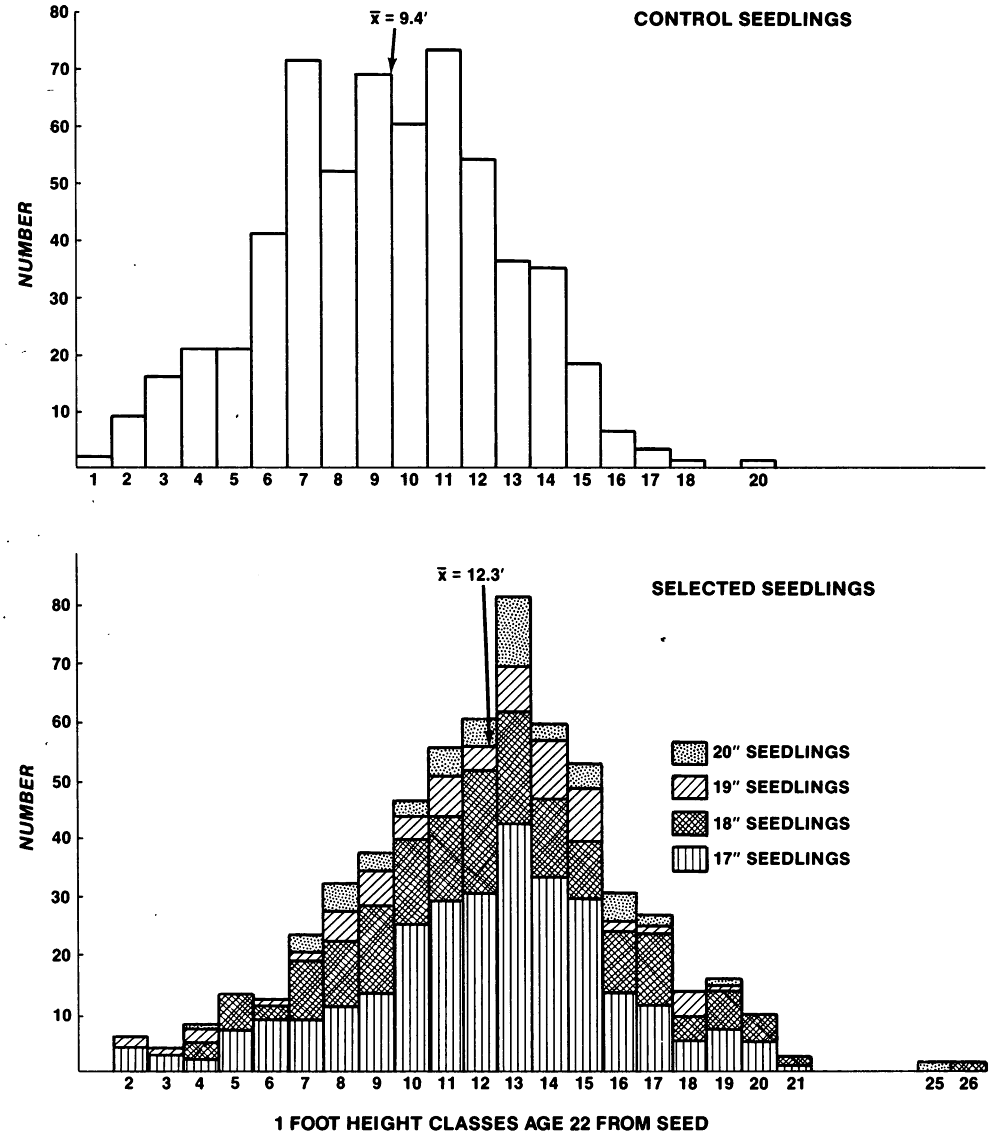

Figure 1.—*Frequency distributon in 1-foot height classes of white spruce trees grown from select and control nursery stock—18 years after field planting.*

should be to incorporate a few of the best trees as parent trees in the initial breeding population. These trees should be selected in the field test as soon as flowering begins. For example, in our study, the selections— those larger than the mean height of the nursery selections plus two standard deviations —would include 14 trees in the 20 foot height class or taller (table 1); 13 trees would represent the nursery selections and one tree the controls.[1]

The results suggest that with a selection differential of 125 percent (selected seedlings 125 percent taller than average) or more, white spruce seedlings can be selected at 4 years in the nursery and about three-fourths of them should continue to be superior growers. There is no evidence that more rigorous selection—equivalent to selecting only 20 inch seedlings in the population studied—would be worthwhile.

[1]*The breeding population would have included many more selections.*

Although the ultimate proof of genetic superiority will require progeny testing of the selected trees, the high correlation between height at 7 and 18 years is evidence that these super seedlings may be genetically superior.

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