Effect of Seed Weight on the Size of Lodgepole Pine and White Spruce Container-Planting Stock

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Selection of seed by weight after normal cleaning, from lots of mixed parentage, resulted in increases in the size, top, and root of eight-wk.-old lodgepole pine and white spruce container-planting stock. Amount of germination was not influenced by seed size to any practical extent.

Data obtained recently by the authors (unpublished) demonstrate that field survival and growth of container-planting stock of lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) and white spruce (*Picea glauca* (Moench) Voss var. *albertiana* (S. Brown) Sarg.) generally improves with the size and vigor of the seedlings at time of planting. Since many authors have reported positive correlations between seed size and seedling size during the first year of growth (Spurr, [1]; Hough, [2]; Langdon, [3]; Burgar [4], this study was undertaken to determine the potential contribution of more rigid control of seed size in the production of eight-wk.-old container-planting stock.

METHODS

Seed samples of both lodgepole pine and white spruce were obtained from the lease area of North Western Pulp and Power Ltd. in the foothills section (Rowe, [5]) of west-central Alberta. They were each from a single lot of mixed parentage and had been previously subjected to a normal commercial cleaning which removed nearly all of the empty and smaller seeds. The mean seed weights were 3.04 mg. (149,-000 seeds/lb.) and 3.90 (116,000 seeds/lb.) for white spruce and lodgepole pine respectively. Quality and purity of both seed lots were excellent and in current practice there would be no hesitation in using the seed directly for the production of container-planting stock.

After an initial sampling to determine the range of weight for each species, four weight classes covering the range were established and 109 seeds in each weight class were selected and weighed to the nearest 0.1 mg. During the selection and weighing all empty and obviously damaged seeds were rejected.

The seedlings were grown in the greenhouse at the Kananaskis Forest Experiment Station. For both species and each weight class, 27 five-oz. plastic containers were seeded with seven seeds each. Three containers of each weight class were then randomly assigned to each of nine contiguous "blocks" on the greenhouse bench. Seedlings were grown for eight wk. under a 16-hr. photoperiod in horticultural perlite and were subirrigated, as required, with a complete nutrient solution. Greenhouse temperature was maintained between 70° and 80°F throughout the experiment.

Germinants were recorded at emergence and the number of cotyledons determined for each. All seedlings were lifted, washed and oven-dried for dry weight measurements of top and root eight wk. after sowing. The identity of individual seeds was maintained throughout the experiment.

The effect of seed weight on number of germinants was examined by

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analysis of variance. The effects of seed weight and number of cotyledons on seedling growth was first examined by an analysis of variance to determine the contribution of bench position and subsequently by a regression analysis combining all bench positions. In the regression analysis top weight, root weight, top/root ratio, and total seedling weight were examined as a function of seed weight and number of cotyledons, separately and in combination.

The model chosen was $Y = a + b$ (Log 10 seed weight) $+ c$ (number of cotyledons).

RESULTS

Seed Weight And Number Of Cotyledons

The range and mean of seed weight and number of cotyledons are shown for each seed weight class in Table 1.

There is a positive correlation between seed weight and number of cotyledons. Simple correlation coefficients of 0.223 for pine and 0.239 for spruce, although low, are significant at the 1% level.

Germination

Germination percentages are shown by seed weight classes in Table 2. There was a significant difference in number of lodgepole pine germinants between the smallest and all larger weight classes. However, there were no significant differences between the three largest weight classes. There were no significant differences between any weight classes for white spruce. Bench position was not significant for either species.

Rate of germination was not measured in this study but emergence was prompt with no indication of an influence by seed weight. These data indicate that little or no gain can be expected in number of germinants obtained by seed size selection beyond that accomplished by a normal cleaning to remove the empty and smallest seeds.

Seedling Size

Analysis of variance of total seedling weight showed seed weight class to be significant at the 1% level for both spruce and pine. Bench position was significant for lodgepole pine but not for spruce. There was no significant interaction between the effect of seed weight and bench position for either species.

Lack of interaction between seed weight and bench position prompted

combination of all bench positions and regression analyses of total, top, and root weight and top/root ratio with seed weight and number of cotyledons as independent variables. The F ratios and coefficients of determination for these regressions are presented in Table 3.

Seed weight contributed significantly to total, top, and root weight for both pine and spruce seedlings. Seed weight did not contribute to

top/root ratio.

Number of cotyledons contributed significantly to total, top and root weight of white spruce seedlings but not of lodgepole pine seedlings. Addition of number of cotyledons after inclusion of seed weight did not improve regression. This probably results from the correlation between seed weight and number of cotyledons previously described.

The regressions are illustrated in

TABLE I. The range and mean of lodgepole pine and white spruce seed weight and number of cotyledons by seed weight classes.

Seed Weight Class	Seed Weight (mg.)		Number of Cotyledons	
	Range	Mean	Range	Mean
	Lodgepole Pine			
1	2.0 — 3.5	2.9	3 — 7	3.82
2	3.6 — 4.5	4.0	2 — 7	4.05
3	4.6 — 5.5	5.0	3 — 6	4.29
4	5.6 — 7.6	6.0	3 — 7	4.25
	White Spruce			
1	2.0 — 3.0	2.8	3 — 8	5.82
2	3.1 — 3.5	3.3	4 — 9	6.04
3	3.6 — 4.0	3.8	4 — 8	6.21
4	4.1 — 6.1	4.4	5 — 8	6.28

TABLE 2. Percentage germination of lodgepole pine and white spruce by seed weight classes.

Seed Weight Class	Percentage Germination	
	Lodgepole Pine	White Spruce
1	66	63
2	80	63
3	88	56
4	79	52

TABLE 3. F ratios and coefficients of determination for regression of seedling weight on seed weight and number of cotyledons for lodgepole pine and white spruce.

Independent Variable	Dependent Variable — Seedling Weight							
	Total		Top		Root		Top/Root	
	F	r^2	F	r^2	F	r^2	F	r^2
	Lodgepole Pine							
Log_{10} seed weight	76.7**	.13	73.2**	.13	72.4**	.13	<1	—
Number of cotyledons	<1	—	<1	—	<1	—	<1	—
Log_{10} seed weight and number of cotyledons	39.3**	.14	37.7**	.13	36.6**	.13	<1	—
	White Spruce							
Log_{10} seed weight	25.3**	0.6	26.6**	.06	13.1**	.03	<1	—
Number of Cotyledons	5.9**	.02	5.2**	.01	7.3**	.02	<1	—
Log_{10} seed weight and number of cotyledons	13.3**	.06	13.7**	.07	8.2**	.04	<1	—

*Significant at 5% level of probability   **Significant at 1% level of probability

Fig. 1 and 2 for pine and spruce, respectively. It is evident that stratification of these seeds by size or weight and using only the larger seeds can result in significant increases in the size of planting stock produced. In the seed lots tested increasing mean seed weight by 1 mg. resulted in a 15 to 16% increase in total seedling weight at eight wk.

DISCUSSION

To be economically feasible, production of container-planting stock requires a high degree of success in individual containers. For this reason Alberta stock is generally produced in a controlled or semi-controlled greenhouse environment. This procedure results in a much higher level of effective seed utilization than is realized in producing conventional bare-rooted nursery stock and justifies the additional costs that would result from selection of seed by size. Assuming a high correlation between seed weight and size, seed selection could be accomplished by differential screening, or, on the basis of weight by an automated device similar to that described by Duffield [6].

Although statistically significant, a relatively small part of the total variation in the size of individual seedlings can be explained by seed weight in this study (Table 3). Bench position has been established as a significant source of variation for lodgepole pine while other sources undoubtedly include uncontrolled variation in genetic constitution (parentage) and rate of germination of individual seeds. Sweet and Wareing [7] and Van den Driessche and Wareing [8], comparing dry matter production of coniferous species found the relative growth rates of large and small seedlings in a first-year population to be the same. Large size differences between individual seedlings were almost entirely the result of small differences set up at, or soon after, germination as a result of rate of germination and seed size. Genetic differences between seedlings in relative growth rates were distributed independently of this. **P&P**

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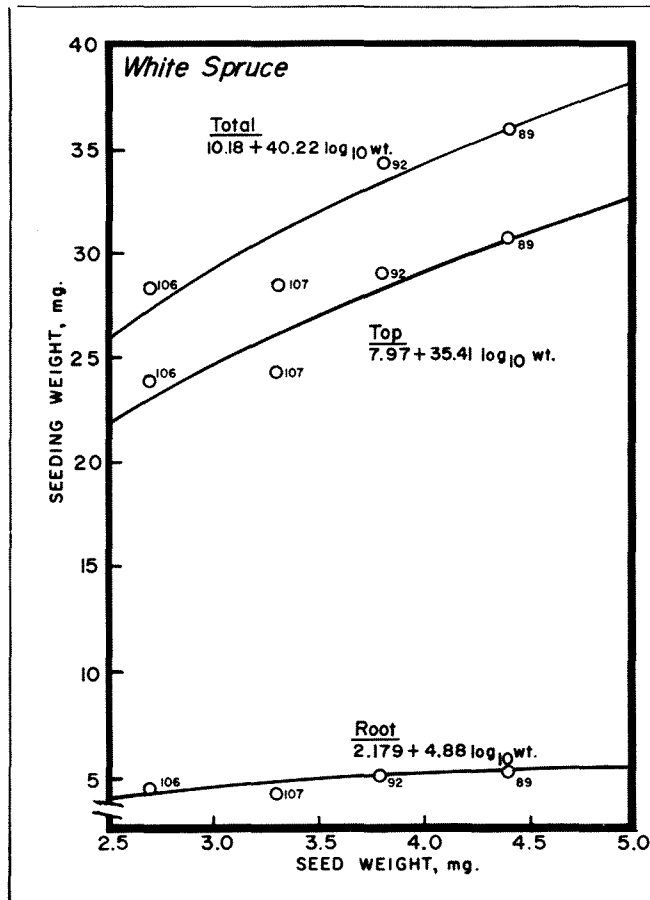
FIG. 1. The effect of seed weight on the growth of 8-wk.-old lodgepole pine seedlings.
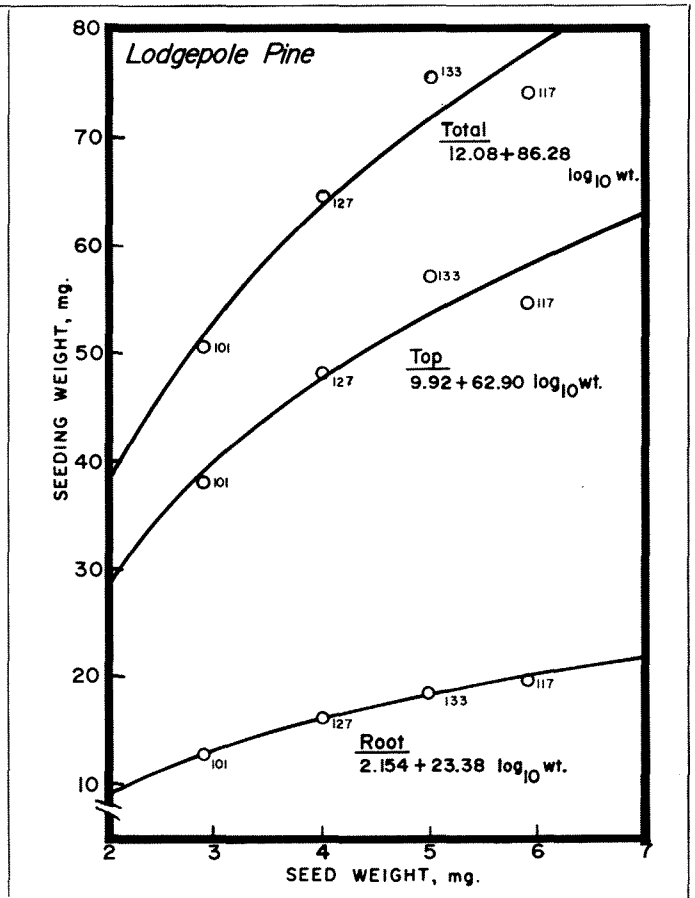
FIG. 2. The effect of seed weight on the growth of 8-wk.-old white spruce seedlings.