



# Frontline

*Forestry Research Applications*

Canadian Forest Service—Sault Ste. Marie

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## HEAVIER BLACK SPRUCE SEEDS PRODUCE MORE VIGOROUS SEEDLINGS

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**CATEGORY:** Cone and seed

**KEY WORDS:** Black spruce, seed weight, seed size, seedling growth

### INTRODUCTION

Perhaps the most critical period in the life cycle of a tree is the transformation of endosperm in the seed to the various components that comprise a living plant. The vigor expressed in this process determines the vitality of the subsequent seedling. The quality of nursery stock for artificial regeneration systems is influenced by this early vigor. Where forest establishment is dependent on seeds germinating under inhospitable field conditions (i.e., natural regeneration), only the most vigorous seedlings are capable of coping with extremes in climatic parameters and competing vegetation.

Black spruce (*Picea mariana* [Mill.] B.S.P.) seeds (Fig. 1) shipped from the Ontario Tree Seed Plant in Angus for silvicultural programs across the province have a high germinative capacity, usually exceeding 95%. In container-stock production under controlled greenhouse conditions, growers often double- or triple-seed to ensure close to full stocking, thereby resulting in a seed efficiency of only 33 to 50%. For bareroot seedling production, where seeds are sown under less climatically controlled seedbed conditions, only 10–15% of the viable seeds produce shippable seedlings (Skeates and Williamson 1979). With direct or natural seeding, seeds are subjected to far more severe conditions than in a nursery. It is likely, therefore, that only the most vigorous germinants on suitable seedbeds have much chance of forming part of a new stand.



Figure 1. These black spruce seeds (5x actual size) still have the seed wing attached. This is removed during seed processing and prior to shipment to nurseries or direct seeding sites.



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Considerable work relating seedling vigor to seed size, density, and/or weight has been done. The effects are most pronounced with large-seeded species, such as the oaks (*Quercus* spp.), where long-term growth productivity increments have been reported. Relatively little research has been done on small-seeded, boreal species. This evaluation emphasizes the importance of black spruce seed quality as a factor in regeneration programs.

## APPROACH

To assess differences in germination and plant performance based on physical seed characteristics, a bulk seed lot was used. The seeds were sieved into eight size classes based on maximum cross-section diameter. With an aspirator, each of these fractions was further separated into four density classes. Seeds of the lowest density were discarded, having insufficient numbers for subsequent evaluations. Each of the remaining 24 fractions was cleaned by hand, and mean seed weights were determined.

Four replications of one hundred seeds each were spread on germination paper placed over a coarse silica sand reservoir. Germination tests were conducted at a constant 20°C and results recorded daily. Germinants were planted into small containers and grown in a controlled-environment greenhouse for 25 weeks.

Height measurements were taken at the cotyledon stage and at 13, 17, and 25 weeks. At each of these stages one-third of the seedlings were lifted, oven dried, and weighed. Regressions of seedling heights and oven-dry weights relative to mean seed weights were developed.

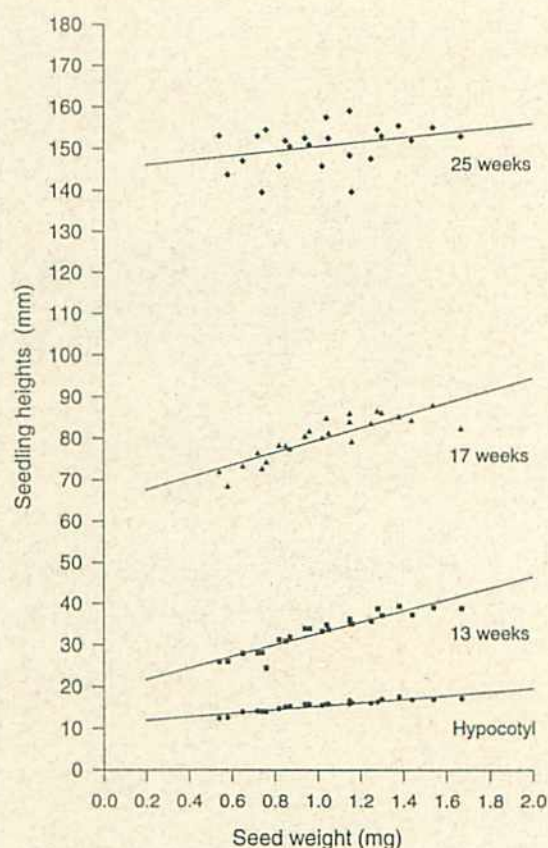
## RESULTS

Germination evaluation based on daily counts provided data on total germination and rate of germination, but failed to reflect the quality of germinants. In this study, radicles emerging from heavier seeds were observed to be thicker and longer, an early indication of seedling vigor. Heavier seeds germinated somewhat more slowly and attained slightly lower total germination than average. These differences were minor, as even the slowest germinating fractions achieved 94% germination in 10 days.

Mean hypocotyl lengths, seedling heights, and oven-dry weights at each assessment were found to be correlated to seed weight (Table 1). The significance of the relationship between seedling height and seed weight diminished with time as other factors influenced plant development (Fig. 2). Production of vegetative material (oven-dry weight) continued to be strongly

**Table 1.** Regressions of mean hypocotyl lengths, average seedling heights, and oven-dry seedling weights assessed at 13, 17, and 25 weeks relative to mean seed weights.

Regression	r	r <sup>2</sup>	F	P
Hypocotyl lengths				
$Y_h = 11.035 + 4.244X$	0.926	0.853	133.04	<0.001
Seedling heights				
$Y_{13} = 18.934 + 13.738X$	0.933	0.870	146.87	<0.001
$Y_{17} = 64.664 + 14.875X$	0.856	0.734	60.57	<0.001
$Y_{25} = 143.266 + 6.766X$	0.402	0.162	4.24	<0.100
Oven-dry shoot weights				
$Y_{13} = 0.0440 + 0.0190X$	0.946	0.895	186.71	<0.001
$Y_{17} = 0.0641 + 0.0407X$	0.874	0.765	71.48	<0.001
$Y_{25} = 0.2636 + 0.1163X$	0.847	0.718	56.04	<0.001



**Figure 2.** Black spruce seedling height relative to mean seed weight at the hypocotyl stage, and at 13, 17, and 25 weeks.

correlated to seed weight throughout the 25 weeks of the study (Fig. 3). Early seedling differences due to variation in seed weight were accentuated in subsequent assessments. At 25 weeks, the regression of mean seedling weight related to seed weight accounted for 72% of the variation.

Differences in seedling height at 13 weeks are illustrated in Figure 4. Height uniformity within each fraction is apparent. Already at this age, these seedlings were comparable to nursery standards for shippable black spruce container stock.



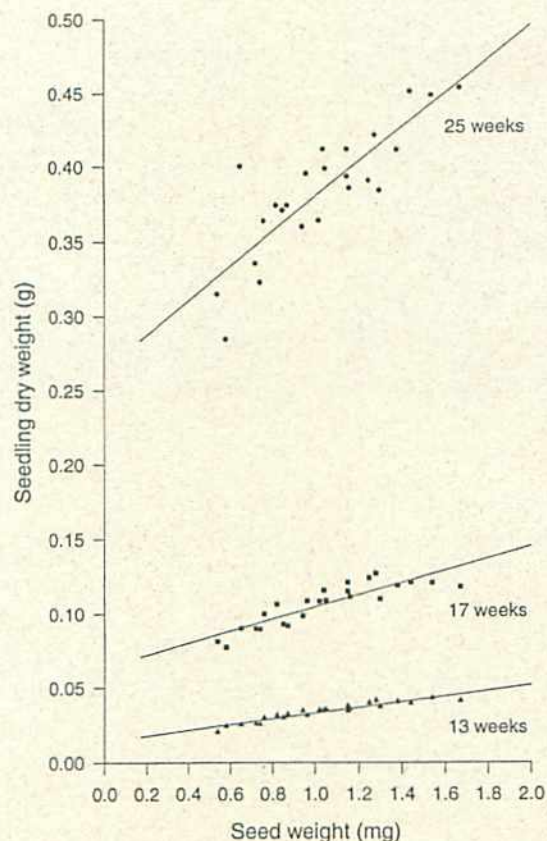


Figure 3. Oven-dry weight of black spruce seedlings relative to mean seed weights at 13, 17, and 25 weeks.

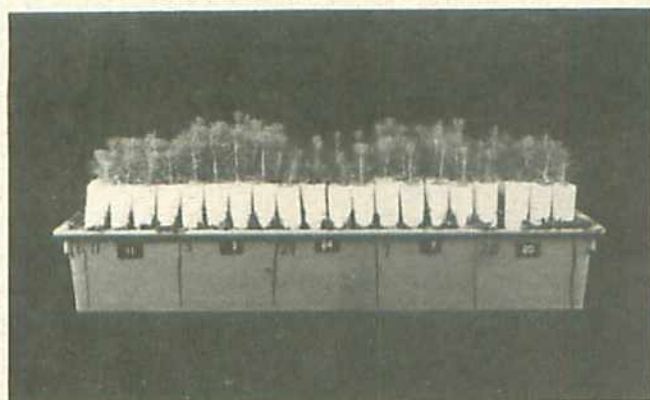


Figure 4. Black spruce seedlings at 13 weeks, exhibiting differences in growth relative to mean seed weights.

## MANAGEMENT IMPLICATIONS

Rapid, early seedling development is important for any effective regeneration system. Healthy, vigorous seedlings have a greater probability of successful establishment, either for stock production or direct seeding. In this study, seedling productivity was strongly correlated to seed weight. The most impressive evidence observed was the size of emerging radicles and the rate of radicle elongation from heavy seeds.

Seed sorting is an operation which, if used judiciously, can provide significant benefits to the forest manager. Various

tree nursery studies in Ontario have shown differences in growth of seedlings related to seed size (Reese 1968, Bunting 1969). Data from the Midhurst Nursery (Skeates 1972), where seed was divided into large and small fractions, indicated that 4-year-old black spruce transplants from large seeds were 12% heavier.

By using expensive greenhousing, a grower can capitalize on differences in early seedling vigor to achieve shippable stock in a shorter period of time. Unfortunately, uniformity of shipping stock, rather than size of stock, may be the nursery manager's primary objective, whereas the field forester is responsible for achieving successful regeneration. Each may, however, manipulate physical seed characteristics to help achieve individual goals.

For direct seedling to be an effective regeneration method, seed sorting may be necessary in order to target seed to the most suitable microsites. The heaviest seed will produce the most vigorous germinants—those most capable of surviving and successfully coping with competing vegetation normally found on the richer forest cutovers. Any treatments that yield heavier seed will obviously contribute to better seedling survival and growth.

The greenhouse study reported here indicates that it is preferable to sort seeds on a weight basis, rather than on the basis of size or density. Unfortunately, no equipment is currently available to separate seeds by weight. For example, separation on a gravity table results in seed fractions of uniform density. However, it is possible to subject seed lots to two separations, followed by a recombining of fractions into lots of uniform seed weight. To date, this has not been tried operationally.

Larger black spruce cones produce greater quantities of seeds (Haavisto et al. 1988), and data from studies designed to monitor seed production (Skeates and Haavisto 1987) suggest that larger cones have higher proportions of heavier seeds. It would, therefore, be of benefit to increase seed quality using procedures that could be conducted during stand management or seed procurement stages.

The most cost effective procedures are usually those providing benefits in the early stages of a continuum. This may best be illustrated by a simple comparison: it is less costly to treat a million potential trees in a laboratory where they occupy a one kilogram container than to conduct silvicultural treatments on a million trees occupying 400 hectares.

## REFERENCES AND FURTHER READING

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