A Case for Improving the Efficiency of Seed Extraction from Black Spruce (*Picea mariana* (Mill) B.S.P.) Cones

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*Viable seed was obtained from cones of black spruce (*Picea mariana *(Mill.) B.S.P.) through 16 extraction cycles. Although seed quality declined somewhat in later cycles, total yields were well above those commonly reported. Seed yields could be improved appreciably if more efficient extraction processes were developed.* Tree Planters' Notes 37(4) : 7-11; 1986.

The current expansion in black spruce (*Picea mariana* (Mill.) B.S.P.) reforestation programs, in both Canada and the United States, has greatly increased the demand for seed of this species. To meet this demand and to reduce the resultant high costs of cone procurement, efforts have focused on developing more efficient cone harvesting techniques and equipment (10). Little attention has been given to the possibility of augmenting seed yields through refinements in extraction processes.

Average yields from large-scale extraction facilities range from 8 to15 cleaned black spruce seed per cone (4, 8). However, the seed potential-the maximum number of seeds a cone is capable of producing (1)-for this species is generally at least five times higher (6, 7). Yields of more than 30 sound black spruce seeds per cone have been reported (5). Undoubtedly the semi-serotinous nature of the cones makes efficient seed extraction more difficult.

During black spruce cone and seed studies we have invariably found seeds remaining in the cones following extraction (8). In order to remove a large portion of the seeds from newly ripened cones, several extraction cycles have been necessary. This article outlines the effects of repeated soaking, drying, and tumbling cycles on seed yields and seed quality when small lot seed processing equipment is used. It also emphasizes the need to ensure that extraction and cleaning procedures for black spruce are as effective as possible, whether for processing small lots or for bulk quantities in large-scale extractories.

Materials and Methods

Three different September collections of newly ripened cones were used: a 1977 collection of 10 cones from each of 5 trees from a 40-year-old lowland stand east of Sault Ste. Marie, Ontario; a 1979 bulk collection from a 110-year-old upland stand near Thunder Bay, Ontario; and a 1980 bulk collection from a 90-year-old upland stand north of Thunder Bay. The cones from Sault Ste. Marie were stored in Kraft paper bags at room temperature (20 °C) for 3 weeks before processing; those from Thunder Bay were stored at 0.5 °C for 5 months.

Two extraction methods were used. With method A, cones were soaked in 20 to 25 °C water for 30 minutes, drip-dried for 1 hour, heated in a drying oven for 22 hours at 50 °C, and then tumbled for 20 minutes. With method B, which was similar to that suggested by Safford (8), cones were soaked in cold water for 4 hours, dried at room temperature for 20 hours, heated at 60 °C for 8 hours, and then tumbled for 20 minutes. In each case, cones were put through 16 repetitions (extraction cycles) of the particular extraction method(s) employed.

In the first experiment, the Sault Ste. Marie cones were processed separately for each tree by method A, while four 10-cone replicates from each of the Thunder Bay collections were processed by each method. Following the 16 extraction cycles, the Thunder Bay cones were dissected and the number of fully developed seeds (1) remaining was tallied. For each combination of cone collection and extraction method, germination tests were then conducted separately on all seeds recovered from each extraction cycle. Seeds were placed on saturated germination paper overlying bleached Kimpak in covered petri dishes and incubated under continuous low-level incandescent light at a constant 21 °C for 28 days (2). Germination (radicle at least 2 millimeters long) was tallied daily.

In a second experiment conducted to obtain greater quantities of seed for a more thorough investigation of the effects of repeated soaking and tumbling cycles on seed quality, 10-liter lots of cones from each of the two Thunder Bay collections were cycled 16 times by method A. These seeds were subsequently dewinged and cleaned. Germination tests were then conducted on four 100-seed replicates per extraction cycle as described above, but at constant temperatures of 10, 21, and 32 °C (2), and with a longer germination period (45 days) for the 10 °C tests.

In addition, after empty seeds were removed by flotation in absolute ethyl alcohol, four more 100-seed replicates from each extraction cycle were weighed. These were then sown on the surface of a 2:1 peat/vermiculite growing medium, placed in a heated greenhouse (18 to 23 °C) lighted 16 hours a day, and watered daily. After they developed primary needles, the seedlings were fertilized every second day with 50 parts per million nitrogen (20-20-20 NPK). Seedling heights and dry weights were determined after 20 weeks.

Germination characteristics were examined in terms of germination capacity (the proportion of full seed that germinated), uniformity of germination (time in days from the beginning of germination until 90 percent of the viable seed had germinated), and germination speed (time in days from sowing until 50 percent of the viable seed had germinated) for each replicate. Following transformation (arcsine) of germination capacity values, data were compared by analysis of variance techniques. Differences among treatment means were established with Tukey's multiple comparison test. Results are reported as mean values per treatment.

Table 1—*Average yields of fully developed seeds per cone following 16 extraction cycles*

Collection	Extraction method	Sample size (cones)	Total seed extracted	Total seed remaining in cone	Viable seed extracted	Percent viability
Sault Ste. Marie	A	50	80.0	ND	37.0	46
Thunder Bay, 1979	A	40	79.8	5.4	48.4	61
Thunder Bay, 1980	A	40	69.4	11.8	34.0	49
Thunder Bay, 1979	B	40	84.5	1.9	47.8	57
Thunder Bay, 1980	B	40	80.2	1.8	44.1	55

ND = not determined.

Results and Discussion

Mean seed yields after 16 extraction cycles ranged from 69 to 85 fully developed seeds per cone and from 34 to 48 viable seeds per cone (table 1), with an average of 2 to 12 fully developed seeds still remaining in each cone. As expected, yields per cycle decreased in later extractions (fig. 1). However, it is noteworthy that the second, third, and often the fourth cycles yielded more seeds than the first. This suggests that specific treatment may be required to enhance cone scale flexing and seed release.

Seed yields per cycle appeared to be affected by both cone storage and extraction methods (fig. 1). Cones stored at room temperature in paper bags (the Sault Ste. Marie collection) had dried and opened to some extent prior to extraction. They yielded greater quantities of seed during the first two cycles with method A than did those stored at 0.5 °C (the Thunder Bay collections). A significantly larger portion of the total seed yield was obtained by the first two or three cycles with extraction method B than with method A.

The proportion of extracted seed that was viable tended to be somewhat larger (by 5 to 15 percent) for the first three cycles, but thereafter exhibited no distinct trend. Average viability (all collections and extractions combined) was 60 percent for cycles 1 to 3 but only 48 percent for cy-

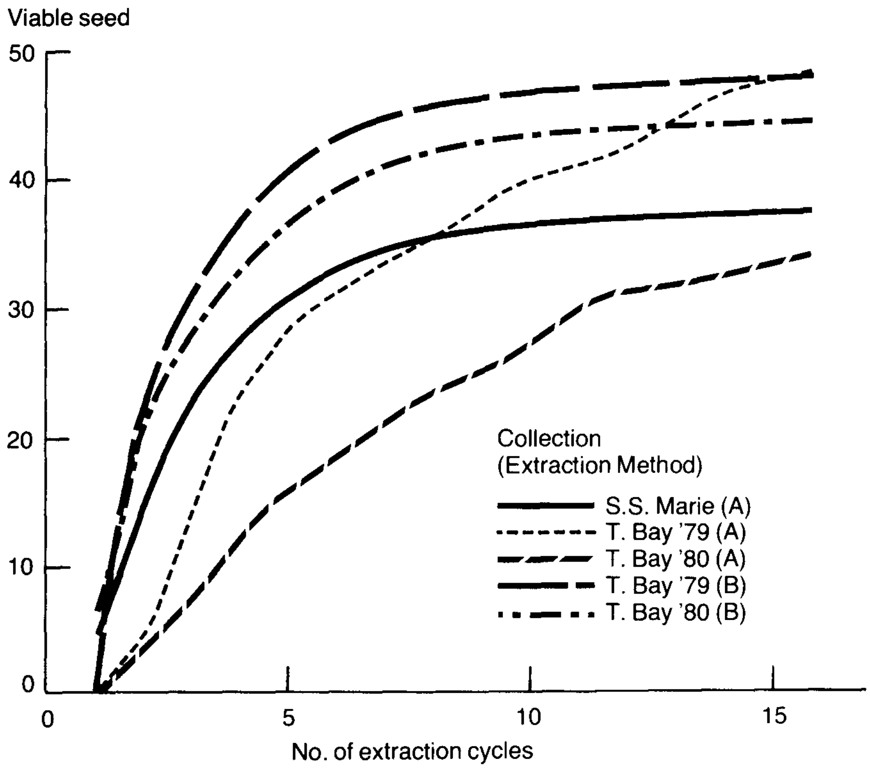

Figure 1—*Cumulative viable seed yields per cone by number of extraction cycles.*

cles 4 to 16. The drop in viability for later extractions reflected an increase in the proportion of empty seed, not a decrease in the viability of full seed. For almost all combinations of seed collection, extraction methods, and extraction cycle, over 90 percent of the full seed obtained was viable.

Although the number of viable seeds per cone can vary dramatically, these results suggest that healthy black spruce cones often contain considerably more viable seeds than are generally extracted. Comprehensive studies are needed to identify more efficient cone storage and extraction techniques to improve yields from large-scale facilities (3). When small lots are processed by methods similar to those employed here, substantial quantities of viable seed (>- 2 seeds/ cone) may be obtained through the sixth extraction cycle. Determinations of the number of viable seeds per cone based on two or three extraction cycles (8) can underestimate the true figure by as much as 50 percent.

To gain a better understanding of the effects of repeated extraction cycles on seed quality, we conducted germination tests at Fraser's (2) lower, optimum, and upper cardinal germination temperatures for black spruce. The germination capacity of the seeds was not significantly different for the first 6 to 7 extractions, regardless of germination temperature. Thereafter it decreased somewhat at 10 °C, but not at 21 or 32 °C. The speed and uniformity of germination tended to decline for later extractions, particularly at 10 °C (figs. 2 and 3). However, there was no significant difference in these two characteristics among seeds from the first 4 to 6 extractions at 10 °C, and from at least the first 5 to 6 extractions at 21 and 32 °C.

Direct relationships have often been reported between seed weight and germination or early growth characteristics. Skeates (9) found a direct correlation between black spruce seed weight and the size of first-year seedlings. In the present study the average weight of full seed decreased somewhat for later extractions, but significant reductions were not realized until the eleventh or twelfth cycle.

The greenhouse study was carried out to determine the effects of repeated soaking and tumbling on germination in a growing medium and on early

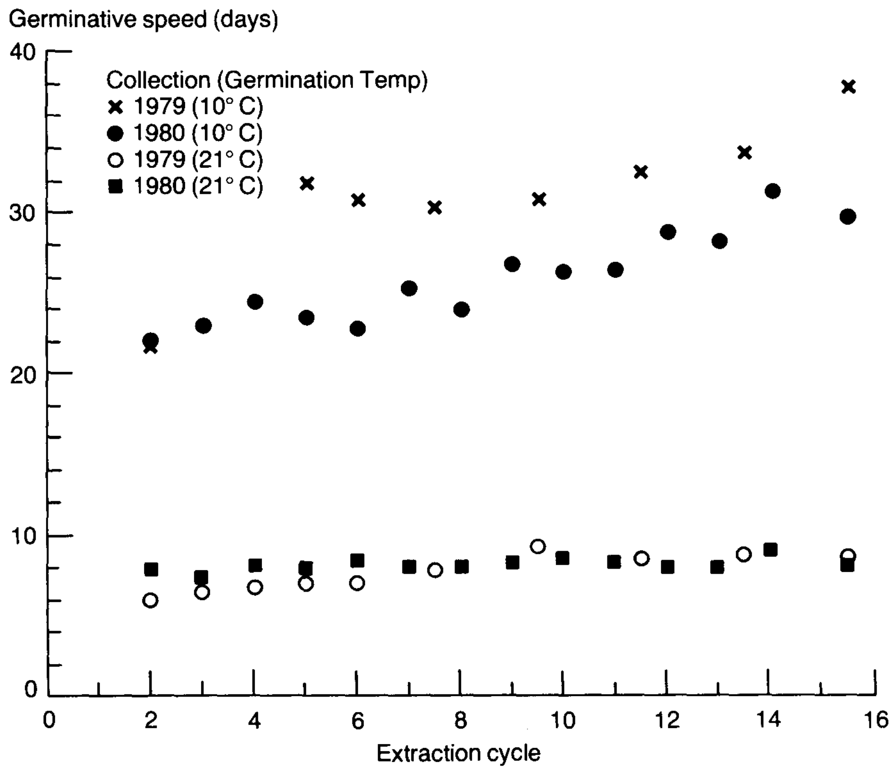

Figure 2—*Germinative speed at two temperatures for successive extractions from two collections. (Results at the 32 °C germination temperature were similar to those at 21 °C, and therefore are not presented.)*

growth. Seeds sown in the greenhouse exhibited germination characteristics similar to those exhibited by seeds incubated in cabinets at 21 °C; there were no significant differences in germination capacity among extractions, but the speed and uniformity of germination declined significantly by the eighth to twelfth cycle. Nevertheless, after 20 weeks, no significant differences were found between extraction cycles for survival, height, and dry weight of the resulting seedlings.

The gradual but consistent drop in the quality of seed from later extraction cycles may be of concern. While seed from later extraction cycles produces healthy and vigorous greenhouse seedlings, it may not perform as well in field conditions where germination temperatures are considerably lower (i.e., in outdoor nurseries or direct seeding programs), or following storage. The drop in seed quality following repeated extractions is likely to vary, depending on the extraction process and number of cycles employed. Hence, while reprocessing cones should be considered as an immediate step to improve seed yields, tests should be conducted to ensure that the additional seed procured is of sufficient quality to warrant this treatment.

Over the long term, refinements in cone storage and extraction techniques likely offer greater potential for increasing yields of high quality seed than does reprocessing with current technology.

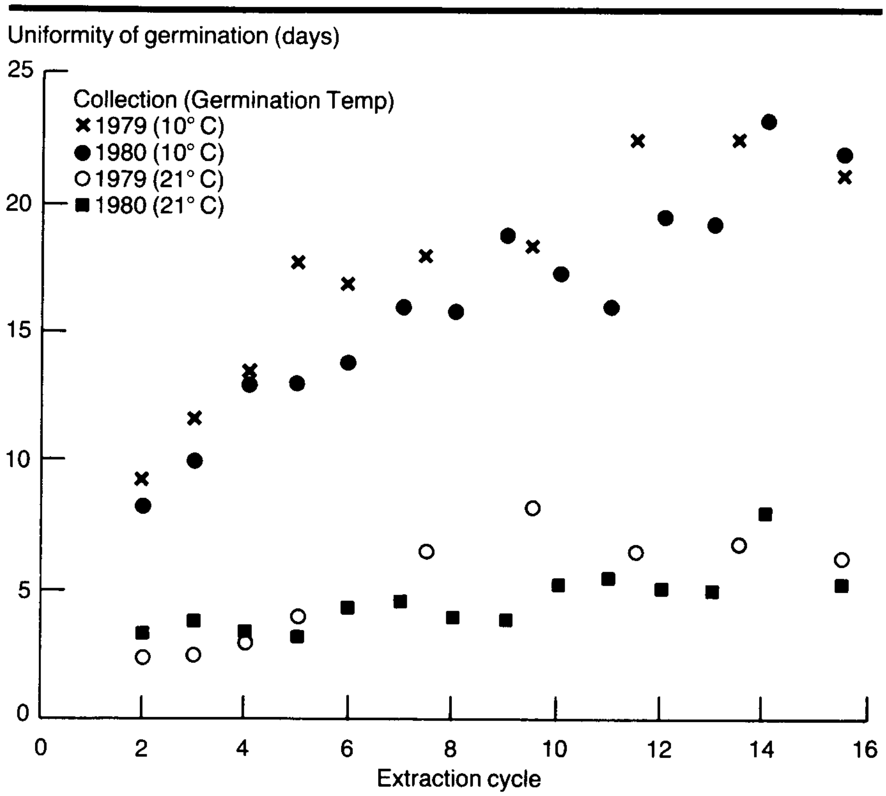

Figure 3—*Uniformity of germination at two temperatures for successive extractions from two collections. (Results at the 32 °C germination temperature were similar to those at 21 °C, and therefore are not presented.)*

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