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Deterioration of Black Spruce Seed During In-Situ Storage and Processing

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Cones of four age classes were collected from 65 individual black spruce (Picea mariana *(Mill) B. S. P.) trees. After three extraction cycles for each cone lot, germination tests were conducted. Seed from older cones exhibited somewhat lower germinative capacity, but extraction procedures did not reduce total viability. However, reduced germinative energy was exhibited by seed of older cones and by seed recovered from second and third extraction cycles. Implications for subsequent production of different stock products are discussed.* Tree Planters' Notes 40(3):5-8 ; 1989.

Black spruce *(Picea mariana* (Mill) B.S.P.) is a semiserotinous species. Depending on weather conditions throughout the year, cones open partially to release seed and then close during dry weather. After maturation, cones thus periodically release seed over a number of years (5). Though seed yields diminish as the cones age, viable seeds have been recovered from 25-year-old cones. Conceivably, year-round collection of cones of varying ages should therefore be possible.

The periodic release of seed in nature is simulated by extraction techniques currently in use at the Ontario Tree Improvement and Forest Biomass Institute. Studies on multiple-cycle extraction procedures have also been conducted at the Great Lakes Forestry Centre of the Canadian Forest Service (6). At both establishments, seed are subjected to 3 and 5 cycles of soaking, drying, and tumbling to release a higher proportion of the total number of seeds.

This study examines the combined influence of the duration of natural in-situ cone storage and the repeated soaking and drying extraction process on seed quality.

Materials and Methods

As part of a long-term study on black spruce seed yield and quality, samples were collected from 13 stands in the Geraldton Forest District of the Ontario Ministry of Natural Resources. In each stand, five trees were felled and their cone-bearing tops removed. For each tree, cones were picked and separated into one of four age classes, i.e., current (1981), 1-year-old (1980), 2-year-old (1979), and 3- to 5-year-old cones (1976-1978). Seed were extracted from each lot of cones by soaking the cones in warm water overnight, drying them in a kiln at 60 °C (140 °F) for 16 hours and then tumbling them for 15 minutes in a rotary sieve. This extraction process was repeated three times, and the seed from each cycle were kept separate. A total of 780 seed lots were thus obtained.

Seeds of each lot were dewinged, conditioned in a drying cabinet to reduce moisture content, and cleaned in the Institute's small-scale seed-processing facilities (7). Two 50-seed samples were drawn from each seed lot and placed in sealed petri dishes with a water reservoir. These dishes were placed in a conventional germinator maintained for 16 hours at 25 °C with lights, alternated with 8 hours of darkness at 23 °C. Temperatures were kept within the range recommended by Fraser (4) for Ontario sources, and humidity was maintained between 80 to 85%.

Numbers of germinating seedlings were recorded daily from the fifth to the ninth day. A final germination count was conducted on the twelfth day; no further germination was seen on day 13. A seed was considered germinated when the radicle exceeded twice the length of the seed. Ungerminated seeds were then cut to determine numbers of filled and empty seeds and germination data were adjusted to a percentage of sound seed.

Results

Germination data are summarized by cone age and extraction cycle in table 1 and illustrated in figure 1. Percent germination attained after 12 days (germinative capacity) for the 12 treatments (3 extractions and 4 cone ages) ranged from 80 to 93%. Cumulative germination after 12 days was similar for current (92%) and 1-year-old cones (91%), whereas values for seed from 2-year-old cones were slightly lower (87%). Seed from the 3- to 5-year-old cones exhibited viability (81%) that was about 10% lower than that of seed from the current year's cones. No trends in germinative capacity were apparent between extractions within any cone age class.

On day 5, the percent germination of first-extraction seed far exceeded those of the other two extractions, regardless of the age class of cones (table 1). For all age classes combined, percent germination of seed from the second and third extraction cycles was only about one-quarter that of seeds from the first extraction (table 2). By day 12, mean percentage germination was similar for the three extractions.

Rate of seed germination (germinative energy) was lower for each successive age class of cones (table 1). In the current and 1-year-old cones of the first extraction, cycle, nearly complete germination (within 10% of the total) had occurred by day 6, whereas with the other two age classes, germination was somewhat slower. The germination results from succeeding extractions showed a marked decrease in germinative energy (fig. 1). When the three extractions for each age class of cones were combined, mean germination on day 5 was 30% for seed of current cones, decreasing to 25, 16, and 9% for those of 1-, 2-, and 3-to 5-year-old cones, respectively. Because of the lower germinative capacity of seed from older cones, differences in germination from day to day continued to the end of the test period. However, these diminished from a 21 % difference at day 5 to 11 by day 12 between current and 3- to 5-year-old cones.

Table 1—*Cumulative percentage germination by day related to cone age and extraction cycle*

	Day 5	Day 6	Day 7	Day 8	Day 9	Day 12
1981 (Current) cones						
First extraction	61	85	88	90	91	91
Second extraction	12	58	82	89	90	91
Third extraction	17	43	70	84	90	93
All extractions	30	62	80	88	90	92
1980 (1-year-old) cones						
First extraction	47	80	86	88	89	90
Second extraction	16	49	78	87	90	91
Third extraction	11	33	66	82	89	92
All extractions	25	54	77	86	89	91
1979 (2-year-old) cones						
First extraction	34	73	83	86	88	88
Second extraction	8	40	70	81	84	85
Third extraction	7	27	57	75	83	88
All extractions	16	47	70	81	85	87
1976–78 (3- to 5-year-old) cones						
First extraction	17	59	73	77	79	80
Second extraction	5	27	64	77	81	82
Third extraction	5	19	48	67	76	82
All extractions	9	35	62	74	79	81

Discussion

In operational germination testing, the nursery superintendent or forest manager has been primarily concerned with germinative capacity as a measure of seed quality. This has been based on the assumption that seeds that germinate represent potential seedlings. Rate of germination has not been con-

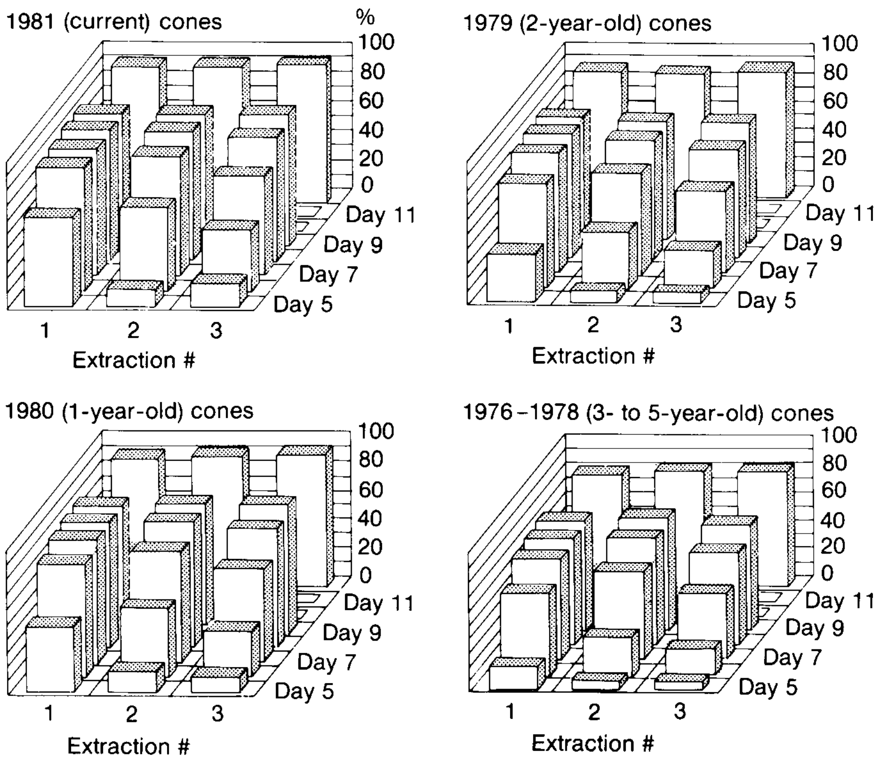

Figure 1—*Germinative energy related to extraction cycle for each of 4 cone age classes.*

sidered as a significant factor in plant performance.

Under optimum germination conditions, differences in germinative energy have had only marginal influence on the duration of germination. Under greenhouse conditions this duration would be expected to increase relative to results from a germination cabinet. On seedbeds under ambient climatic conditions, black spruce germination (emergence) has been observed to take place over a period of weeks. Seed sown onto seedbeds in the forest have even more constraints to normal development.

Time of germination has been shown to have a considerable influence on early stock performance in this species (8). Stresses during the critical germination period can result in slower rates of germination, reducing the season available for growth, and thus resulting in smaller plants at the end of the production cycle. Reduced seed vigor as indicated by lower germinative energy can contribute to decreased germination and losses during the period of emergence and early development. The resultant number of vigorous seedlings could therefore be much lower than might be expected based on germinative capacity under optimum conditions.

In this study, germination was virtually complete by the twelfth day. The percentage of seeds that germinated was only somewhat lower for seeds from older age classes of cones. However, the rate of germination suggested a lower germinative energy for seeds from older cones. Natural in-situ aging seems to have reduced seed quality, a factor the forest manager should consider when determining collection strategies. It is recommended that black spruce seed stocks should not be augmented in poor crop years by collection of cones older than 1 year unless absolutely necessary.

Yields of seed vary with extraction methodology. Fleming and Haavisto (3) have shown that per-cone seed yields can be increased by continuing to extract seed for up to 16 cycles of wetting, drying, and tumbling The potential yields from black spruce cones would appear to

Table 2—*Cumulative mean percentage germination by day related to extraction cycle, combining 4 cone age classes*

	Day 5	Day 6	Day 7	Day 8	Day 9	Day 12
First extraction	40	74	82	85	87	87
Second extraction	10	44	74	84	86	87
Third extraction	10	30	60	77	84	89

be much higher than normally considered (6). Though higher yields should be achievable, the methodology of successive cycling reduced germinative energy in this study. This technique appears to be a form of artificial aging contributing to deterioration in seed quality. There is a need to reexamine and possibly redevelop extraction technologies in order to achieve close to potential yields without unduly affecting germinative energy.

Aging of seeds in the cone and further artificial aging through extraction processes may be more harmful than just loss in germinative energy. Delouche and Baskin (2) have suggested possible deterioration of genetic material in the seed as it ages. Deterioration may proceed even before losses are detectable in germination tests.

The influence of germinative energy on initial plant development as indicated by vigor testing (9) was not assessed in this study. The effect of such influence would be expected to vary for different stock products, i.e., container seedlings, accelerated transplants, bareroot seedlings, and transplants, each of varying age class. However, the negative effects of natural and artificial aging on germinative energy would indicate a need to consider age of cones and extraction technologies as factors influencing seed quality and hence stock quality.

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