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# CAN WE ATTAIN OUR SEED PRODUCTION GOALS WITH INTERIOR SPRUCE

Progress Report
1985

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# CAN WE ATTAIN BRITISH COLUMBIA SEED PRODUCTION GOALS FOR INTERIOR SPRUCE?

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ABSTRACT: The British Columbia seed production target is 4,000 viable seeds per interior spruce ramet per year by age 15 (15 years from grafting). In 1983, 10-year-old ramets produced an average of 65.4 cones and 27.6 filled seeds per cone, resulting in a mean filled seed production per ramet of 1,805. One year later production was substantially lower at 46.46 filled seeds per ramet when the average number of cones per ramet was 10.1 and filled seeds per cone was 4.6. Based on this information, orchard location, and associated cone induction trials, the chances of attaining the seed production target are discussed.

## INTRODUCTION

Estimated cone and seed yields from grafted ramets and future seedling requirements are used to determine the size of seed orchards in the cooperative British Columbia Tree Improvement Program. Failure to meet seed production targets will limit the positive impact of our reforestation and tree improvement programs on the forest economy. Therefore, the accuracy of seed production estimates must be continually updated to determine the level of seed production from orchards in relationship to seedling demand. If these figures are not updated, seed collections from natural stands and from orchards may become out of balance with seedling demand, resulting in considerable financial loss.

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Paper presented at the Conifer Tree Seed in the Inland Mountain West Symposium, Missoula, MT, August 5-6, 1985.

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For example, if seed production from the orchards falls below target levels, collections from natural stands will be required to reach the seed production goal. If orchard production is not determined in time to collect seed from the natural stands or there is not a good inventory of seed from the designated seed zone, the seed shortfall could result in a slowdown in reforestation. This would result in a loss of desirable species on productive growing sites, which would eventually lead to a decrease in the annual allowable cut for the area.

Projected annual seedling requirements for British Columbia (BC) indicate that interior spruces (*Picea glauca*, *P. engelmannii*, and their hybrids) will continue to be the major reforestation species. Recent data for the BC interior show that anticipated annual demand by the year 2000 for interior spruce will be 86.1 million seedlings (Albricht 1985). This high interior spruce seedling demand has resulted in the allocation of a major part of tree improvement funding into grafted clonal seed orchards and associated breeding activities for the species. To date about 30 ha (96 acres) of spruce seed orchards have been established.

Our spruce seed production estimates are based on extrapolation from extremely limited data. Expectations are that by age 15 (15 years from grafting) each orchard ramet should be producing an average of 100 cones with 40 filled seeds per cone for a total of 4,000 viable seeds per ramet. Relatively recent literature indicates that this estimate may be high. Ten- to 19-year-old white spruce ramets had considerably lower production of viable seeds (2,262 per ramet) but higher cone yields of 174 cones per ramet (McPherson and others 1982). The relatively small number of filled seeds per cone (13) has also been reported for black spruce (*P. mariana*) (McPherson and others 1982; Verheggen and Farmer 1983).

Our first clonal orchard was established at Skimikin, BC (lat. $50^{o}47'$, long. $119^{o}24'$) in 1979 and therefore is too young to provide meaningful seed production information. Fortunately, in 1976 G. Kiss, BC Ministry of Forests spruce breeder, established a breeding arboretum at Vernon (lat. $50^{o}15'$, long. $119^{o}14'$) which is located in the hot, dry Okanagan Valley. The spruce program was originally located considerably farther north ($3^{o}$ of latitude); however, greater strobili production was anticipated in the Okanagan Valley, and this has been confirmed (Kiss, 1978). Based on this fact, the majority of spruce seed orchards are located in the Okanagan Valley.

## WHAT ARE CURRENT SEED PRODUCTION YIELDS?

To update spruce seed yield estimates, cone and seed data was collected from clones in the oldest section of the East Kootenay breeding arboretum in 1983 and 1984.

### Materials and Methods.

The ramets in the East Kootenay breeding arboretum located at Vernon, BC were planted at a 5.5- by 5.5-m (18- by 18-ft) spacing on an orthic black chernozem soil (Grandview Series) from 1976 through 1979. The 1.5 ha (3.7 acre) arboretum consists of 127 clones planted in clonal row plots (4 ramets per clone). Scions were collected from ortets located between latitudes $49^{o}01'$ and $50^{o}52'$, longitudes $114^{o}18'$ and $116^{o}36'$, elevations between 854 and 2,012 m (2,800 - 6,597 ft) and grafted onto 2-year-old rootstock using the side veneer technique. The 235 ramets selected for the study were grafted from 1972 through 1974, planted in 1976, and were about 2 m (6.6 ft) tall in 1983.

Bulk collections of 10 cones per ramet were made in the fall of 1983 from those ramets that had produced a sufficient number of cones. Cones were oven dried for 12 hours at $50^{\circ}$ to $70^{\circ}$ C ($122^{\circ}$ to $158^{\circ}$ F). Seed was extracted by hand, dewinged, and the filled seed fraction was determined using a single-tube South Dakota blower. A sample of filled seeds in this fraction was counted and weighed. This weight was then divided into the total seed weight to determine the total number of filled seeds. Since this figure represented 10 cones, the total weight was divided by 10 to determine the number of filled seeds per cone. The study was repeated in 1984.

Results and Discussion.

In 1983 the average number of cones per ramet was 65.4 (range 0-500) and the average number of filled seeds per cone was 27.6 (range 0-89). This resulted in a mean filled seed production per ramet of 1,805, which contrasted with the significantly lower production figure of 46.46 filled seeds per ramet that occurred in 1984 when the average number of cones per ramet was 10.1 (range 0-250) and the average number of filled seeds per cone was 4.6 (range 0-20). This cone and seed production information is summarized in table 1. According to local observations, in 1983 there was good male strobili production and the cone crop was the largest since the establishment of the arboretum. The 1984 cone and pollen crop was classified as very light, using the classification criteria outlined by Dobbs and others (1976). About 97 percent of the total seed production during these two years occurred in 1983. Cone crops in spruce stands were of similar proportion. In 1984 at a 15-year-old East Kootenay spruce clone bank near Prince George (about $3^{\circ}$ of latitude north of Vernon) there were absolutely no cones and in 1983 there was a medium crop. This clone bank consists of ramets from the same clones as the ramets used in this study. This supports the inverse relationship between cone production and latitude.

As illustrated in figures 1 and 2 there was an extremely unequal clonal contribution to seed production in both the marginal and bumper crop years at the arboretum. The discrepancy between clonal number (79 clones in 1983 compared to 85 clones in 1984) is attributed to seed extraction difficulties during 1983. The ANOVA for both years indicates significant differences in cone production per clone (0.01 level). In an unmanaged seed orchard the pollen mix and cone production can be very poor, as shown in the 1984 data.

Ideally, we want equal amounts of pollen and cone production per clone to maximize the genetic quality of the seed. An unequal strobili distribution per clone implies increased selfing levels and therefore decreased genetic quality. This problem could also be aggravated by nonsynchronous flowering in the orchard or lack of a pollen crop of significant size. Utilization of supplemental mass pollination techniques rapidly becomes an essential orchard management tool for maximizing the quantity and quality of seed.

## CONE PRODUCTION FROM TRANSPLANTED RAMETS

Our seed orchard staff has consistently observed substantial increases in spruce cone production in the year following seed orchard establishment. For instance, no cones were observed on 111 3-year-old ramets when planted at a nursery. One year after transplanting the ramets into a seed orchard, each ramet had an average of 88 cones. A similar number of ramets from the same clones that had been established in the orchard 2 years earlier had an average of only two cones per ramet.

Average heights of the two groups of ramets were quite similar (transplanted trees 134 cm (4.4 ft), orchard trees 140 cm [4.6 ft]). Obviously, transplanting accounted for the additional cone production. Eighty-one of the transplanted trees were over 100 cm (39.4 ft) tall and had an average of 115.07 cones per ramet; the remaining 30 trees had an average of 14.9 cones per tree. The data from this study are summarized in table 2. With increasing size of transplanted ramets there was a pronounced increase in cone production in the year following transplanting.

## DISCUSSION AND CONCLUSIONS

If the goal of 4000 filled seeds per ramet by age 15 is to be reached, a 67 percent increase in seed production will be required in 4.5 years. The breeding arboretum is not managed as a production seed orchard; however, the cone production data suggest that unmanaged seed orchards could yield well below their biological potential. Further decreases in seed production could occur if cone and seed insects "discover" our seed orchard sites. Presently the seed orchards are isolated from natural spruce stands and are relatively free of insects and disease.

Each interior spruce cone could potentially produce about 200 seeds (Owens and Molder 1984). Up to 100 filled seeds per cone have been counted in local natural spruce stands. A conservative assumption as to the potential for filled seed production in a managed spruce seed orchard might be 90 seeds per cone. Using methods discussed by Bramlett and Godbee (1982), "seed efficiency" averaged over both the study years was only 18 percent ([16.1 seeds per cone realized ÷ 90 seeds per cone potential] x 100). Supplemental mass pollination would be a useful tool to increase seed set.

Once we have the cones we must be able to harvest them. Flower and cone abortion losses of up to 75 percent of the crop have been observed for other species such as coast Douglas-fir (Pseudotsuga menziesii) (Bartram 1982). We don't know the magnitude of the losses for interior spruce.

In spite of the potential problems, our seed orchard managers should be able to meet our seed production goals. We know that transplanting shock substantially increases cone production. Our physiologists are attempting to duplicate these results in operational seed orchards using various combinations of root pruning, drought stressing (heat and water), GA 4/7 treatments, and fertilizing. In combination with booster pollination and insect and disease control we have the potential to exceed our seed production target. With a good quantity of genetically superior seed we are off to a good silvicultural beginning.

ACKNOWLEDGMENTS

The author is indebted to C. Bartram for data assistance, J. Konishi and M. Albricht for technical advice, and G. Kiss for providing the ramets.

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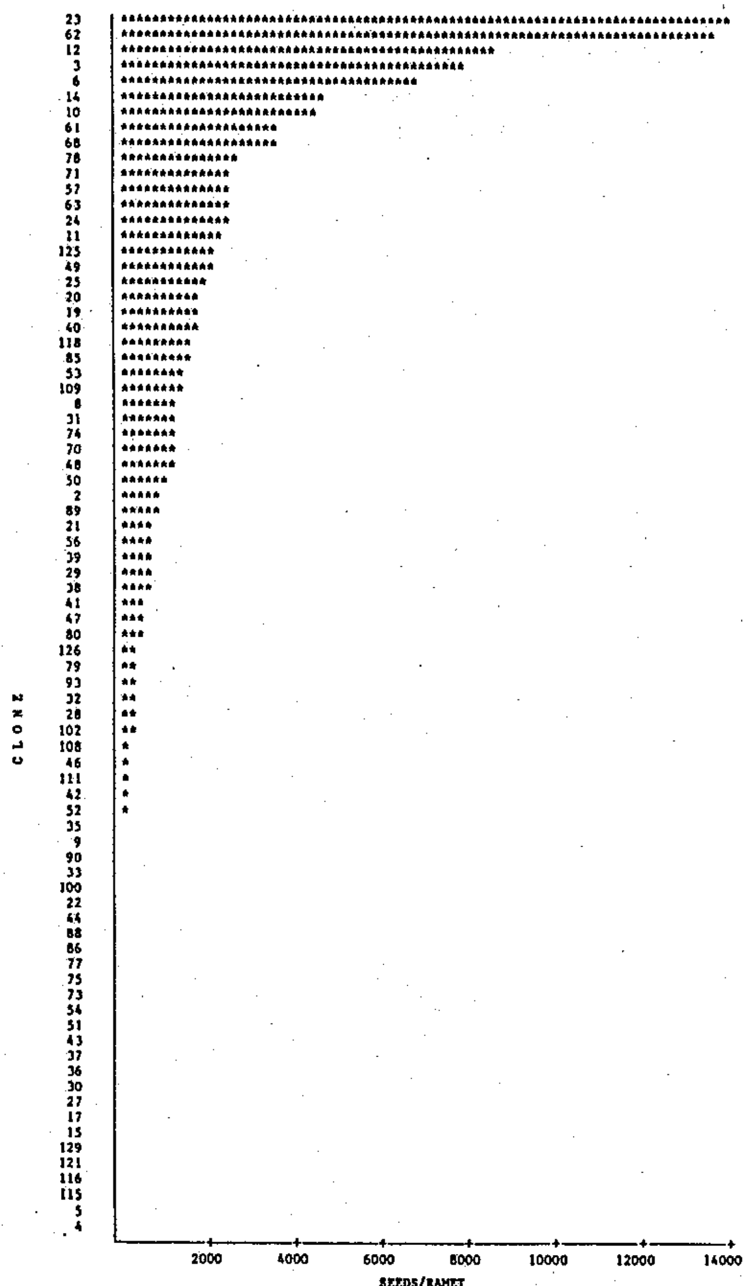


Figure 1.--Mean seed contribution per ramet by clone in 1983.

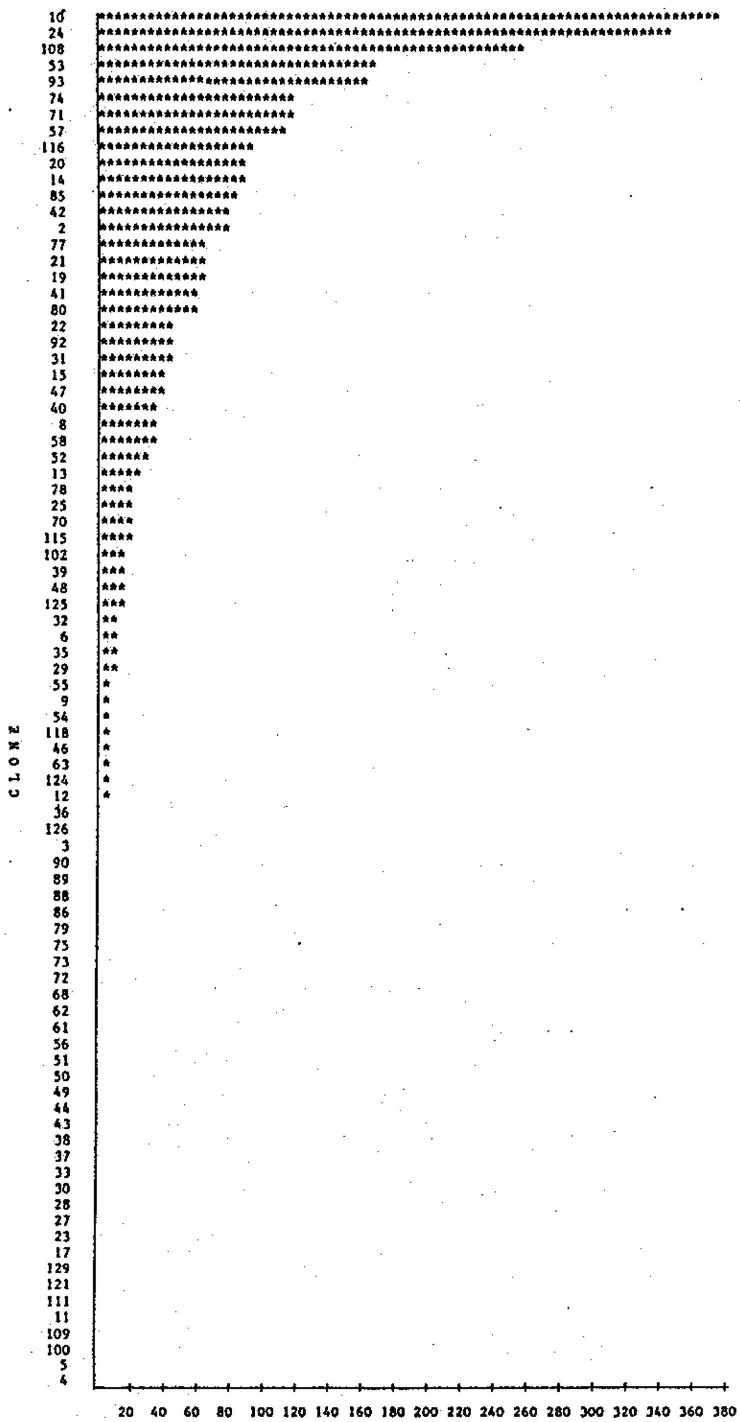


Figure 2.--Mean seed contribution per ramet by clone in 1984.

Table 1.--Summary of cone and seed production from 10-year-old and 11-year-old interior spruce ramets located at Vernon, BC

| Variable | 10-year-old ramets (1983 data) | 11-year-old ramets (1984 data) |
|---|---|---|
| No. of clones | 79 | 85 |
| No. of ramets | 235 | 235 |
| Average no. of cones | 65.4 (range 0-500) | 10.1 (range 0-250) |
| Average no. of filled seed per cone | 27.6 (range 0-89) | 4.6 (range 0-20) |
| Mean filled seed production per ramet | 1805 | 46.46 |

Table 2.--Cone production from 5-year-old transplanted interior spruce ramets

| Variable | Ramets planted in 1981, data collected in 1984 | Ramets planted in 1983, data collected in 1984 |
|---|---|---|
| Seed orchard planning zone | Shuswap Adams | Shuswap Adams |
| No. of ramets | 111 | 111 |
| Avg. ht. of ramets | 140 cm | 134 cm |
| Avg. no. of cones per ramet | 2 | 88 |
| No. of ramets > 100 cm in ht. | 101 | 81 |
| Avg. cone production per ramet > 100 cm | 2.198 | 115.07 |
| No. of ramets $\leq$ 100 cm in ht. | 10 | 30 |
| Avg. cone production per ramet $\leq$ 100 cm | 0 | 14.9 |