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SOWING RULES FOR CONTAINER NURSERIES 1/

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Abstract.--Sowing is the first important step in the implementation of a container reforestation program. The effect of poor seed distribution and germination is transmitted throughout the nursery phase, and beyond. An example is drawn from a styroblock container nursery in British Columbia. The effect of alternative sowing procedures on styroblock seedling yields and production costs is examined with the help of a simple computer model. The best method depends on management objectives. Preliminary sowing rules for B.C. styroblock nurseries, and a research program are proposed.

INTRODUCTION

Sowing is the first important link in the long chain of operations that ends in the production of acceptable containerized tree seedlings ready for planting. While mistakes and misfortune at any point in the chain can reduce the quantity and the quality of the seedlings produced, a poor beginning severely limits the ability of the nursery manager to produce a satisfactory crop. No matter how well the nursery is equipped, organized or staffed, and no matter how well seedlings are cared for, poor seed distribution will throw a proverbial wrench into the finely wrought works.

In British Columbia, where the styroblock container (Kinghorn 1970) has been used on an operational scale since 1971, several problems resulting from poor seed distribution have emerged. The version of the seed distribution machine that is currently in use (Nyborg 1972) is not very accurate. This, combined with seed viabilities in the 50-80% range, has led nursery staff to adopt various ways of avoiding blank cavities in the styroblock after sowing and germination. Styroblocks have been passed through the only machine available two or three times, then scanned and empty cavities filled by hand. These actions have proven costly and not particularly successful: an unacceptably high proportion of cavities remained blank after germination; many cavities contained more than one germinant creating an extra thinning task; and the loss of seed was an irritant to a reforestation agency faced with a seed shortage. We expect that the same problems will be encountered in any container seedling nursery. Nursery operations are based on the batch processing principle and factors which decrease the yield of output (seedlings) from each batch (container unit) increase output costs and the space required to produce a given amount of output.

In response to these problems, our study had three objectives:

1. to examine the relationship between seed distribution, seed viability, and the production of germinants or potential seedlings4/ in the styroblock;
2. to examine the effect of alternative sowing procedures on potential seedling

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4/The term 'potential seedling' is used to describe one or more germinants in a container cavity after germination or the single germinants that remain after thinning. Mortality takes place from this stage to the point when they can be considered acceptable seedlings, and thus the adjective 'potential' is applied.

output and nursery costs at different levels of seed viability; and,

3. to suggest rules for improving sowing procedures immediately and recommend research and development activities to improve sowing in the future.

SEED AND GERMINANT DISTRIBUTION

The example of seed and then germinant distribution, and final nursery output shown in Table 1 is not exceptional. Nursery output figures for 1971-1973 confirm that the average output for all species hovers around the 75% mark if the correct growing procedures are followed. Approximately two-thirds of the fall down is attributable to the poor distribution of germinants, with the remaining third due to poor seedling development or seedling mortality.

Germinant distribution depends upon the performance of the seed distribution machine and seed viability.

Seed Distribution Machine

Styroblocks are fed into the seed distribution machine by conveyor, and pass beneath a rotating drum. Seeds drop onto the drum and are affixed to holes spaced in the same pattern as styroblock cavities by vacuum pressure created within the drum. The seeds are released by cutting off the vacuum pressure and applying a light air pressure inside the drum when they are correctly positioned over the styroblock.

The precision with which the seeder picks up and drops seed into each cavity is subject to the following factors:

- amount of vacuum created pressure inside seed drum;
- amount of air pressure created inside seed drum;
- amount of air pressure applied outside drum by jets directed to displace loosely held seeds which tend to cluster about one or two more firmly held central seeds;
- seed characteristics--size, shape, purity;5/
- size of drum holes;5/ and,
- seed bounce from styroblock cavities when seed is released from drum.

Tests of the seeder have shown that the seed distribution patterns can be controlled within the general limits shown in Fig. 1. To obtain a high proportion of single seeds the machine operator must accept a relatively high proportion of blanks. If, on the other hand, a reduction in the number of blanks is required, an increased proportion of multiple seeds per cavity must be accepted.

Seed Viability

Accurate information about seedlot viabilities is essential for sowing decisions because the number of germinants in each cavity is a product of the interaction between seed distribution pattern and viability. When viability is as low as 30%, many seeds must be sown in each cavity to ensure that there is a germinant in every cavity. On the other hand, if viability is very high, say 95%, then precise seeding is required to avoid a high proportion of cavities with more than one germinant.

5/Seed size and shape influence the precision of the seeder. To improve the seeder capabilities, different hole sizes have been manufactured to suit different species. The purity of seed also affects the seed distribution pattern because pieces of resin or dirt are picked up in the same way as seed.

Table 1.--An example of the effect of seed distribution on germinant distribution and seedling output.

Production stage	Seedling stage	No. of seeds or trees per cavity 0	1	2	3	4	5+	Total
1st sowing	seed	6.5	68.5	21.0	3.3	0.5	0.1	100
2nd sowing	seed	0.4	9.0	49.9	27.8	9.5	3.4	100
germination	germinant	13.5	37.6	35.8	10.3	2.3	0.5	100
thinning	germinant	13.5	86.0	0.5	-	-	-	100
packaging	acceptable 1-0 seedlings	23.0	77.0	-	-	-	-	100

Data Source: Koksilah Container Nursery, Duncan B.C. 1973. Western hemlock seedlot No. 1300, Viability - 59%

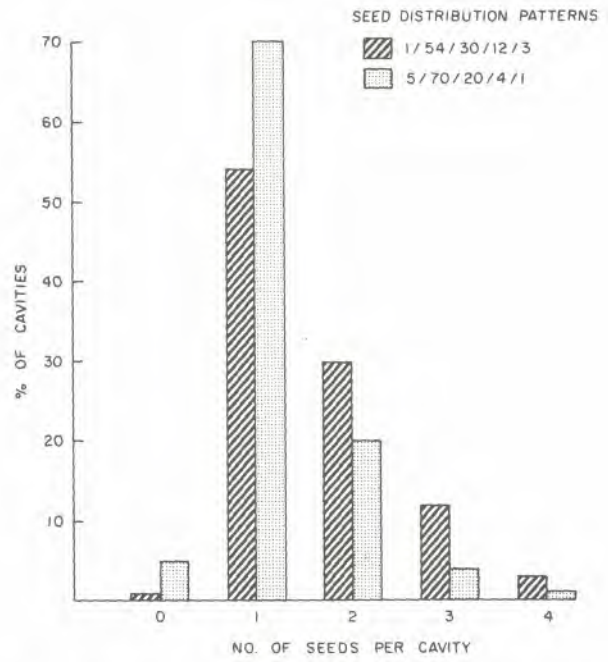

Figure 1.--Possible seed distribution patterns for the styroblock seeder.

ALTERNATIVE SOWING PROCEDURES

The styroblock nursery manager can gain some measure of control over the output and cost of potential seedlings by varying sowing procedures in response to seed viability or operational cost. The amount of seed delivered to each block can be controlled either by changing the seed distribution pattern within set limits, or by repeating any pattern more than once, and cavities without seed can be filled in by hand sowing. Unfortunately, predicting the effect of any alternative procedure , using seed viabilities at intervals of 5 or even 10 per cent, is a tedious task. As a consequence, sowing rules up to the present have been based more on intuition than on fact. To ease the decision-making burden, we constructed a simple computer model which calculates the output and cost of potential seedlings for any given sowing procedure, operational cost structure, and seed viability (Fig. 2).

We set out to demonstrate its value, and to satisfy our second objective by examining the currently available options of single versus rnultip.. sowir a at different seed distribution patterns, and cavity inspection after sowing. Costs, based on --hose recorded in detail for 1971-1972 at Surrey Nursery, B.C., were used. Potential improvements in sowing procedures using a new seed distribution machine, a technique for replacing blank cavities with germinants, and a minimum seed viability limit were also examined.

Single Versus Multiple Sowing

The effect of passing a styroblock through the seeder more than once is illustrated in Figure 3. For any given seed viability, multiple sowing increases the number of potential seedlings. A change from a seed distribution pattern that delivers a high proportion of single seeds but also delivers no seed to a number of cavities, to one which reduces the number of blanks to a minimum (see Figure 1), accomplishes the same feat but less dramatically. What effect does the increase have on production cost?

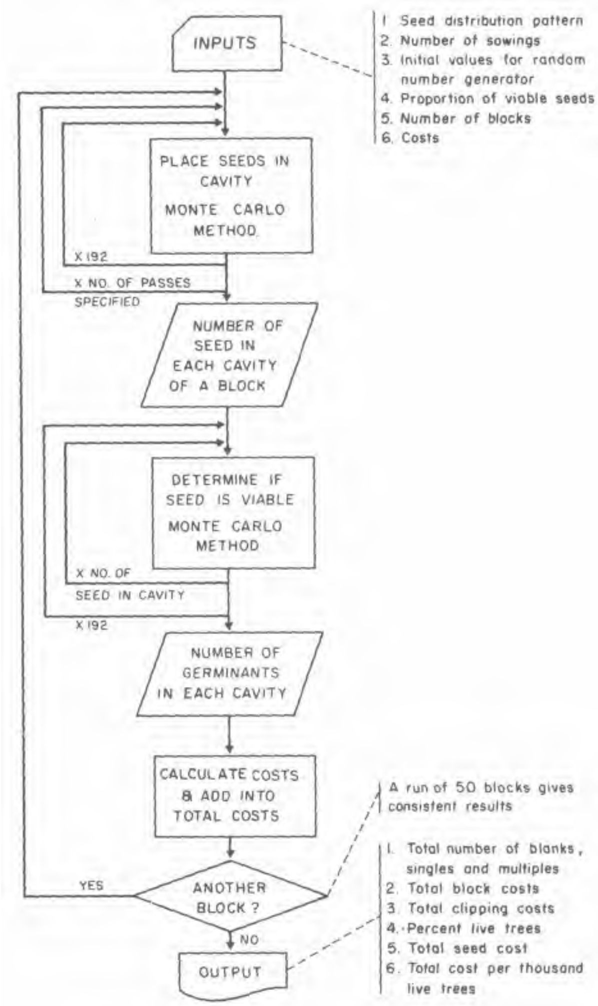

Figure 2.--A simplified flow chart for the computer model of seed distribution and germination.

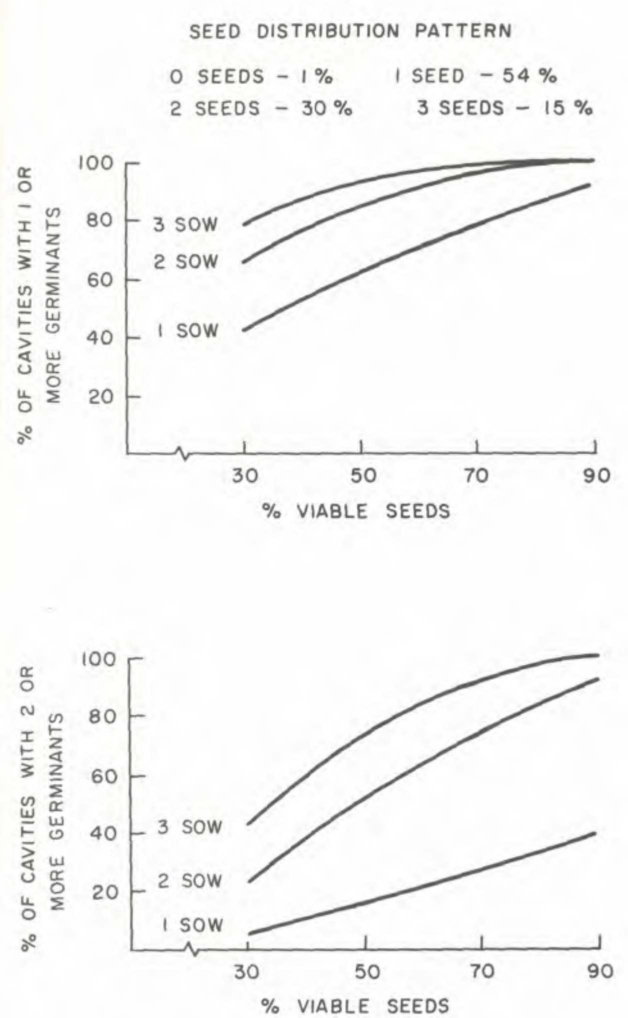

Figure 3.--The effect of multiple sowing on the distribution of germinants.

Increasing the amount of seed distributed to each block also increases the number of unwanted germinants. Nursery studies have shown that the time required to thin blocks can be calculated from the following equation:

$Y = 22.4 + 1.9X \ (R^2 = 0.92)$
where Y is the time in seconds for one person to thin a block
and X is the number of cavities thinned per block

When allowances are made for moving from block to block, and for delay time, the cost of thinning blocks with an average of 50 percent multiple germinants would be $0.22 per block at current B.C. labour rates ($4.00 per hour).

Multiple sowing is most expensive if only one seeder is available and blocks have to be passed through the machine more than once. This procedure doubled or tripled sowing cost when nursery staff were forced to use it. The use of two or more machines would greatly reduce the cost, but the newly developed twin hole seed drum which permits double sowing on one pass through the seeder is cheaper still. Only the additional costs of seed and thinning operations and the very minor equipment cost of an extra seed drum are incurred.

As Figure 4 shows, even the largest additional costs of multiple sowing are offset by increases in potential seedling yield and production costs per seedling are lowered when seed in the lower range of viability is used. This stems from the very high proportion of total nursery cost that is expended before the seed germinates. And, as might be expected, the actual break even points shown in Figure 4

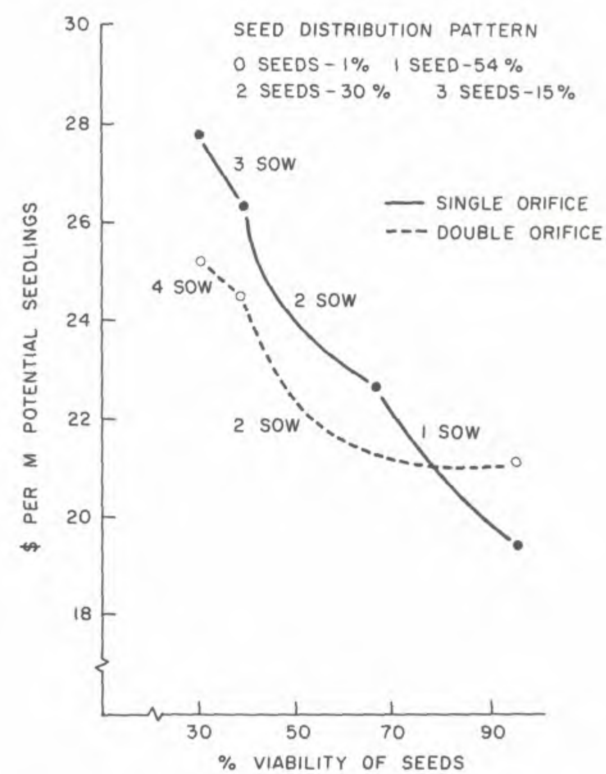

Figure 4.--Minimum cost curves for sowing using the single and twin hole seed drum.
N.B. - the following costs were used to plot the curves:
Fixed nursery costs - $2.20/block
Sowing cost - .26/pass/block
Seed cost - .40/thousand (D. fir)
Packaging cost - 4.27/thousand trees

are very sensitive to changes in the cost of capita], or container for example. They are much less sensitive to changes in the cost of thinning.

Our examination of costs also showed that, within the limits of the seeder, the seed distribution pattern which minimizes the number of blanks was superior. A small increase in potential seedlings has a much larger effect on overall costs than a large increase in the number of cavities with more than one germinant. However, the effect of changing patterns on output and cost was small in comparison to the effect of multiple sowing.

Cavity Inspection After Sowing

The inspection of machine sown blocks, or container units, and hand sowing of blanks is effective when the seed distribution machine is very inaccurate. If the number of blanks exceeds 10 per cent, the cost of inspection is offset by the increase in the number of potential seedlings. However, if the seeder is functioning correctly, with blanks less than 5 per cent, inspection is a wasted effort.

Increased Accuracy of Seed Distribution

What would be the effect on seedling output and production costs if a machine capable of delivering a single seed to each cavity 99 times out of 100 was designed and developed? Assuming that the use of such a machine would neither increase nor decrease sowing cost, we found that great accuracy is not desirable unless seed of the highest viability (> 85 percent) is used. At lower, and more common, viability rates, the present seeder results in lower seedling costs and more seedlings per block as long as 1 or more seeds are delivered to each cavity with 99 per cent accuracy. Only at the very high viability levels is the advantage of creating more potential seedlings by delivering more seed reduced and overtaken by increased thinning costs.

Seed Viability Limit

Nursery managers can keep their average output of potential seedlings above 90 per cent and their costs at a minimum by rejecting seedlots with viabilities of less than 70 percent. This very attractive procedure is dogged by the problem of what to do with the remaining seedlots. One possibility would be to sow them in bareroot nurseries, but this would probably increase the cost of all nurseries more than if the seedlots were sown in styroblocks. Bareroot nursery costs have almost the same structure as container costs and low crop yields have a startling effect on the seedling production costs.

A more sensible course of action would be to improve the viability of a seed lot by identifying and removing some part of the non-viable portion. Up to $100 per pound could be spent in raising seedlots of below average viability above the single-sowing break-even point without increasing their present production costs.

In sorting the low viability seed, it seems likely that some part of the viable seed will be unavoidably lost. This loss could be significant if seed stocks of a particular provenance are low. However, if the gains in viability are large enough to warrant the use of single rather than double sowing as the minimum cost procedure, less seed will be required to produce the same number of potential seedlings and the sorting loss would be offset to some calculable extent.

Replacing Blanks After Germination

The whole problem of choosing the best sowing procedure is reduced if a technique for replacing blanks after germination is available. How much it is reduced will depend on the cost of the technique and the number of blanks to be replaced.

One idea currently under consideration in British Columbia conjures up the prospect of micro-containers within mini-containers. Single seeds would be sown in micro-containers and the containers with germinants would be sorted out and injected into larger blank cavities. The cost of this technique is almost certain to be expensive since it involves all the standard costs, except growing costs, and should be accompanied by accurate sowing. Nevertheless, the savings involved in increasing crop yields of potential seedlings from the 90 to 95 per cent levels reached by minimum cost sowing procedures are large when divided by the small number of germinants required. We estimate that up to $12 per thousand replacement germinants could be expended without increasing present overall seedling production costs.

CONCLUSIONS

The choice of the best sowing procedure depends on the nursery management situation. Without information on management objectives, seedling demands, seed supply, budget levels and available space, no one can decide to minimize costs or maximize seedling yields, except by fiat.

Minimum cost sowing procedures are appropriate when a nursery has no restrictions on growing space, or seedling orders can be filled in the available space. Diagrams such as Figure 4 could then be useful guides to the development of sowing rules which make the best use of public or private funds. When seedling orders exceed the maximum production potential of a nursery run according to minimum cost sowing rules, the rules must be altered. In private nurseries, efforts to intensify crop yields can be guided by the marginal cost principle: production from the limited facility should be expanded only so far as the extra costs equal the value of the additional seedlings produced. Beyond this point, net profits are reduced and only customer goodwill is maintained. For the public nursery manager, the clear profit motive is replaced by the rather muddier goal of keeping within an often flexible annual budget. The budget sets an upper limit on the ability to meet seedling demands and the manager must pursue the alternatives for increasing crop yields, in order of increasing additional cost, until his budget is exhausted.

If seed supplies of certain provenances are limited, nursery customers may request that the maximum number of seedlings be produced from the available seed, with an upper cost limit, or regardless of cost. Total output per pound of seed then becomes the criterion of success and the advantages of accurate sowing are emphasized.

These general comments make only a small contribution to the nursery managers' decision problem. More specific rules are needed to cope with actual situations. In 1974 and in the foreseeable future, the B.C. Forest Service styroblock nurseries are faced with problems of overwhelming seedling demands as the provincial reforestation program expands, limiting growing facilities, and shortages of seed of many provenances. For this situation three preliminary rules seem appropriate:

1. double sow all seedlots with the seeds set to deliver a minimum number of blanks through the twin hole seed drum;

2. no seed lots of viability less than 60 per cent to be sown, thus keeping the average output of potential seedlings above 90 percent; and,

3. seedlots in very limited supply should be sown only in emergency situations (e.g. fire rehabilitation) unless single sowing, with the seeder set to maximize the number of single seeds, produces more than 90 per cent potential seedlings.

For the longer term future, potential sowing procedures already discussed offer a considerable combined potential for relieving the decision problems. Accurate sowing of high viability seed, combined with a technique for replacing blank cavities with germinants, will allow the nursery manager to reach very high crop yields while keeping costs at a minimum. A successful integrated research program would have a substantial impact.

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We wish to thank our colleague, G.A. Birchfield, formerly Economics Research Assistant, Pacific Forest Research Centre, for his numerous contributions and the staff of Surrey and Koksilah Nurseries for their co-operation.

Question: Do you plant containers with two seedlings in them? What do you expect the results of this kind of planting to be?

Arnott (on Vyse-Rudd paper): We don't allow two seedlings to be planted together. In a 7-year-old plantation, where paired trees had been planted together, most were still codominant. Growth of either was being jeopardized by the presence of the other. It was quite obvious that one tree was better than leaving two or more planted together.