Germinant Sowing in South Africa

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Germinant sowing is operational for tree nurseries in South Africa. The technique reduces seed costs for eucalypts and pines. Filled-cell percentage is usually near 98%. Seed efficiency at many North American container nurseries can be improved by adopting either germinant sowing or single sowing technology.

INTRODUCTION

Managers at most container nurseries attempt to produce one tree per container cell. This makes efficient use of containers, bench space, and potting media. Three different approaches are used to minimize the number of empty cells. A traditional approach in North America is to sow multiple seeds per cell and to thin cells that have more than one seedling (Schwartz, 1993; Wenny, 1993). A second method (developed in Sweden) involves removing dead and unfilled seeds prior to sowing (Simak, 1984; Donald, 1986). Since the germination percentage can be increased to over 93%, this practice promotes the sowing of one seed per cell. A third method involves germinating seeds prior to sowing and sowing only germinated seed. Although sowing germinants by hand is a common practice in tropical nurseries, mechanical sowing of germinants is not common in North America. However, in South Africa, mechanical sowing of germinants has been operational since 1986. This paper reviews some of the advantages of germinant sowing and suggests that managers of container nurseries in North America consider adopting this technology.

SEED EFFICIENCY

Seed efficiency is defined as the percentage of plantable seedlings produced per pure live seed (South, 1990). Achieving high seed efficiency is important when using valuable, genetically improved seed or when seed cost is high. For example, in the southern United States, seed efficiencies were often low (e.g., 33%) when nursery stock was not genetically improved. However, today, most pines are genetically improved and seed efficiencies in bareroot nurseries often exceed 80%. When seed are valued at 0.3¢ or more, there is a strong economic incentive for improving seed efficiency (South, 1990). In North America, seed efficiency in container nurseries can be low if multiple seed are sown in each cell. For example, in British Columbia, seed efficiency from container nurseries is expected to range from 28% to 40% for regular seed (Table 1). At some operational container nurseries, seed efficiency can be less than 35% (Eremko et al., 1989). In some cases, seed efficiency can be higher at bareroot nurseries (Table 2). In general, container nurseries will have high seed efficiency when single-sowing (i.e., one seed per cell) is used. Many managers will single-sow when the germination percentage is more than 90%. However, some recommend sowing two or more seeds when the germination percentage is less than 95% (Wenny, 1993). Four or more seeds are sometimes recommended if germination is less than 70%.

Table 1. Recommended seeding rates, oversowing factor (i.e., extra cells sown to ensure meeting production targets) and expected seed efficiency from container nurseries using 1994 B.C. Ministry of Forests sowing rules.

	Regular seed			Seed orchard seed		
Germination percentage	Seed/ cell	Oversow factor (%)	Seed efficiency (%)	Seed/ cell	Oversow factor (%)	Seed efficiency (%)
100	2	25	40	1	40	71
95	3	30	40	1	45	72
85	3	35	30	2	30	45
75	3	40	32	3	40	32
65	4	50	26	4	50	26
55	4	60	28	4	60	28

Table 2. Seed efficiency from container and bareroot nurseries in British Columbia during the 1980s (data from Eremko et al., 1989) and seed costs from a dealer in New York.

	No. plantable seedlings/pure live seed		Pure live seed cost
Species	Container (%)	Bareroot (%)	(¢)
Coastal Douglas-fir	23	32	0.21
Western hemlock	27	25	0.09
Western larch	28	28	0.22
Lodgepole pine	30	41	0.08
Ponderosa pine	22	38	0.80
Western white pine	53	66	0.54
Sitka spruce	35	43	0.20
Grand fir	22	24	0.42
Pacific silver fir	59	23	0.59

When seed costs and thinning costs are considered, the logic for multiple sowing is less attractive (Space and Balmer, 1977). Table 3 compares the cost of production when using seed that costs 0.3¢ per pure live seed. In this example, seeding plus thinning costs were 34% greater for double-sowing than for single-sowing. Although seed and thinning costs make single-sowing more attractive, many nurseries in North America continue to multiple-sow and thin. In North America, a typical laborer can thin about 40 trees/min.

Table 3. Estimated sowing and thinning costs associated when producing 10 million seedlings.

	Two seed/cell	One seed/cell	One germinant/cell
Cells needed	10,666,666	13,333,333	10,204,082
Germination (%)	75	75	75
Seeds required	21,333,332	13,333,333	13,333,333
Blanks expected	666,666	3,333,333	204,082
Excess trees	6,000,000	0	0
Seed cost ($)	64,000	40,000	40,000
Sowing cost ($)	5,333	6,666	5,102
Thinning cost ($)	24,000	0	0
Cost of carrying empty cells ($)	5,3332	6,666	1,633
Total costs ($)	98,666	73,332	46,735

IDS SYSTEM

In Sweden, tree seed are routinely sorted to remove dead and unfilled seeds. The Incubation-Drying-Separation (IDS) procedure is used on *Pinus sylvestris* and *Picea abies* to produce seed with a high germination rate (98%). Researchers in North America have not developed the technique to an operational level. However, this method has promise for several North American species (Donald, 1986; Edwards, 1989; Malek, 1992; McRae et al., 1994) and could eliminate the need for multiple sowing.

GERMINANT SOWING

In South Africa, filled-cell percentages of 98% to 99% are consistently achievable with the use of germinant sowing. Originally developed in the United Kingdom, the concept was refined and simplified in South Africa. Much of the initial work was conducted in Natal by Bryan's Machinery in cooperation with Sappi Forests. The equipment is now available in North America from a distributor in Ontario. With the old system, seed were germinated in a tray, "pricked out" by hand, and transplanted into containers. With this method, about 150,000 *Eucalyptus grandis* seedlings could be produced from a kg of seed. With germinant sowing, the number of seedlings increased to 600,000/kg. With a value of $2000/kg for genetically improved seed, the fluid drilling system reduced seed costs by $10/thousand seedlings.

In addition to improving seed efficiency, labor costs were reduced at the Sappi Nursery. With the old system (manual transplanting into cells), the labor for 1-million plants was 175 person-days. With fluid drilling, labor was reduced to 51 days. These are savings in the sowing operation. There are large savings in not having to thin the crop after emergence. At the Sappi Nursery, one machine can produce 10-million plants/year. An added benefit is that seedling crops are very uniform because all the seed is sown at the same stage of germination.

The key to success with fluid drilling is sorting dead from live seed. The seed sample must be clean and well-graded. This factor is imperative in order to successfully separate germinated from non-germinated seed. For pines and eucalypts, the germination fluid is water. If seeds are well-graded (of the same size and mass), germinants will imbibe water and will change in size but not mass. Therefore, germinants have a lower specific gravity than non-germinants. The imbibed (swollen) seeds are separated using a sugar solution. Seed are placed in a small amount of water and a concentrated sugar solution is slowly added until imbibed seeds float to the top. These are then removed from the solution with a tea strainer. If seeds are germinated for too long, the radicals become elongated and tangling can result in multiple sowing. Ideally, the seed coat should be broken with the radical about to emerge.

After separation, germinated seeds are placed in a fluid trough just below the vacuum head. Special needles on the vacuum head are dipped in the fluid and when removed, several germinants may adhere to each needle. A water rinse is used to remove excess germinants while one remains attached due to the vacuum. Needle size (hole size) varies from 0.1 to 0.9 mm. Correct needle selection is important (too small = misses; too large = doubles). Vacuum setting is also important (too low = misses; too high = doubles). Cycle time will vary with seed size. Large pine seeds require that the nozzles have a longer period in the fluid trough in order to become properly attached. For pine, almost no doubles occur, but with the smaller eucalypts seed, about 10% of the cavities will have doubles.

Bryans' Miniseeder will sow 60 to 225 trays/h (128 cavities/tray). The system can sow one row at a time or up to ¼ tray at a time. At the Sappi Nursery, four machines are used for sowing. Fluid drilling is used for all eucalypts and pines when germination percentage is less than 90%. Dry, single-sowing of pine is still practiced when germination is greater than 89%.

Two models of precision drilling machines are available in North America. Both *are currently sold by INNO-TEC I.T.U. Inc. Thunder Bay, Ontario. The Miniseeder has a cost of $25,000 while a full size Precision Fluid Drilling System can cost about* $48,000. The full-size machine can sow full trays and production is about 66% faster than the Miniseeder. Currently, two, full-size fluid drilling machines are being used in Canada and one in Mexico.

If the purchase of a germinant sowing machine (@ $48,000) would eliminate double-sowing, the potential savings in reduced seed costs and thinning costs could pay for the machine after only 10 million seedlings. For example, the estimated difference in cost between double-sowing and germinant-sowing could amount to $5100 per million seedlings (Table 3). This savings results when each pure live seed is worth 0.3¢ and thinning costs amount to $4 per thousand thinned plants. In regions where seed is provided to nurseries free of charge (e.g., Canada), savings in thinning costs could pay for the machine after sowing 20 million seedlings. However, in situations where both seed and labor are free or inexpensive, it may be difficult to justify investing in germinant sowing.

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