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 singlesowing technology.
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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 was developed in Sweden and involves removing dead and unfilled seeds prior to sowing (Simak 1984, Donald 1986). This method involves three steps (incubation, drying, and separation, or IDS. Because the germination percentage can be increased to over 93%, the IDS treatment promotes the sowing of one nongerminated seed per cell. A third method involves germinating seeds prior to sowing and sowing only germinated seed. Although the concept of fluid drilling (sowing germinants in a viscous gel) was introduced into the Southern United States in early 1980's (Barnett 1983 & 1985), mechanical sowing of germinants is not common in tree nurseries in North America. However, in tree nurseries in South Africa, mechanical sowing of germinants has been operational since 1986. The South African method suspends the germinated seed in water instead of mixing germinants in with a viscous gel. 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 by 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 (for example, 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 cent (that is, 3/10th of 1 cent) 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 woods-collected seed (table 1). At some operational container nurseries, seed efficiency can be less than 35% (Eremko and others 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 (that is, one seed per cell) is used. Many managers will single-sow when 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%.

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 cent 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 nursery worker can thin about 40 trees per minute.

IDS System

In Sweden, batches of tree seeds are routinely sorted to remove dead and unfilled seeds. Fully imbibed seeds are incubated (kept in warm, moist conditions) for a few days and then are placed under controlled drying conditions. During the drying process, dead

Table 1-*Recommended seeding rates, oversowing factor (that is, extra cells sown to ensure meeting production targets), and expected seed efficiency from container nurseries using 1994 BC Ministry of Forests sowing rules*

	Woods-collected seed			Seed orchard seed		
Germination percentage	No. seed/ cell	Oversow factor (%)	Seed efficiency (%)	No. 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 1980's and seed costs from a seed dealer*

	Seed efficiency (%)		Cost of pure
Species	Container	Bareroot	live seed (¢/seed)
Coastal Douglas-fir ***(Pseudotsuga menziesii*** (Mirb.) Franco)	23	32	0.21
Western hemlock *(Tsuga heterophylla* (Raf.) Sarg.)	27	25	0.09
Western larch (*Larix occidentalis* Nutt.*)*	28	28	0.22
Lodgepole pine (*Pinus contorta* Dougl. ex Loud.)	30	41	0.08
Ponderosa pine (*P. ponderosa* Dougl. ex Laws.)	22	38	0.80
Western white pine (*P. monticola* Dougl. ex D.Don)	53	66	0.54
Sitka spruce *(Picea sitchensis* (Bong.) Carr.)	35	43	0.20
Grand fir *(Abies grandis* Dougl. ex D.Don) Lindl.)	22	24	0.42
Pacific silver fir *(A. amabilis* Dougl. ex Forbes)	59	23	0.59

Note. seed efficiency data from Eremko and others (1989).

seeds loose water at a greater rate than live seeds. After drying, seeds can be separated by density separation (dead seeds float and live seeds sink). The IDS procedure is used on Scots pine *(Pinus sylvestris* L.) and Norway spruce *(Picea abies* (L.) Karst.) to produce non-germinated 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 and others 1995) and could be used to eliminate the need for multiple sowing.

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

	Two seeds/ 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 ($)	24,000	0	0
Cost of carrying empty cells ($)	5,333	26,666	1,633
Total costs ($)	98,666	73,332	46,735

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* W. Hill ex Maid. seedlings could be produced from 1 kg of seeds. With germinant sowing, the number of seedlings increased to 600,000/kg. With a value of $2,000/kg for genetically improved seeds, the germinant sowing 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 germinant sowing, labor was reduced to 51 days. These are savings in the sowing operation. In addition, there are subsequent 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 seeds are sown at the same stage of germination.

The key to success with this technique is sorting dead from live seeds. The seed sample must be clean and well graded (of the same size and mass). This factor is imperative in order to successfully separate germinated from nongerminated seeds. For both pine and eucalypts, the germination fluid is water. If seeds are well graded, germinants will imbibe water and will change in size but not mass. Therefore, germinants have a lower specific gravity than nongerminants. The imbibed (swollen) seeds are separated by using a sugar solution (Taylor and Kenny 1985). Seeds are placed in a small amount of water and a concentrated sugar solution is added slowly 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 water trough just below the vacuum head. Special needles on the vacuum head are dipped in the water and when removed, several germinants may adhere to each needle. A water rinse is used to remove excess germinants while a single germinant 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 remain for a longer period in the fluid trough in order for the seed to become properly attached. For pine, almost no doubles occur but with the smaller eucalypt seeds, about 10% of the cavities will have doubles.

Bryans' Miniseeder will sow 60 to 225 trays/hour (128 cavities/tray). The system can sow one row at a time or up to one quarter of a tray at a time. At the Sappi Nursery, four machines are used for sowing. Germinant sowing is used for all eucalypts and for pine when the 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 costs $25,000 and a full-size Precision Fluid Drilling System (figure 1) about $48,000. The full-size machine can sow full trays and production is about 66% faster than the Miniseeder. Currently, two fullsize machines are in use in Canada and one in Mexico.

If the purchase of a germinant sowing machine (at $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

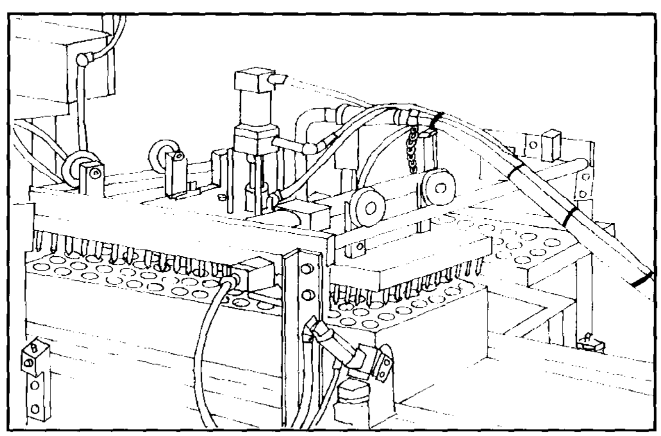

Figure 1—*The ITU Precision drilling system (from a photograph courtesy of Jim Reed, Thunder Bay, Ontario).*

double-sowing and germinant-sowing could amount to $5,100 per million seedlings (table 3). This savings results when each pure live seed is worth 0.3 cent and thinning costs amount to $4/thousand thinned plants. Where seeds are provided to nurseries free of charge (for example, Canada), savings in thinning costs could pay for the machine after sowing 20 million seedlings. However, in situations where both seeds and labor are free or inexpensive, it may be difficult to justify investing in germinant sowing.

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