NURSERY SEED EFFICIENCY CAN AFFECT GAINS FROM TREE IMPROVEMENT

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Abstract.-- The efficiency of a tree improvement program can be greatly affected by the degree of seed efficiency in the nursery. The gains from tree improvement can be 50% greater from a nursery with 90% seed efficiency than from a nursery with 60% seed efficiency. However, because the nursery and tree improvement are usually operated by different divisions, the goals of the nursery manager may not include the long-term objective of optimizing future wood production. This can result in nursery management practices that waste a third or more of seed from the best genetic sources. If high seed efficiencies are to be routinely achieved, State Foresters and Corporate Executive Officers must provide the incentives and adequate support to maintain the best personnel and equipment.

Additional Keywords: *Pinus taeda* L., economics

Tree improvement in the South has evolved to the point where in 1987, more than 20,500 pounds of second-generation seed were produced (Jett 1988). Although a considerable amount of money has been invested in genetic improvement, few organizations have invested additional money in their nurseries for conserving the improved seed. Some State Foresters and some Corporate Executive Officers are apparently satisfied with obtaining a seed efficiency of 66% for their best improved seed. (Seed efficiency is defined as the number of plantable seedlings in a nursery bed at time of lifting as a percentage of the number of full live seed sown.) This results because of the decision to operate the nursery program and tree improvement program separately, with different goals. The tree improvement program operates with the long-term goal of increasing future wood production while the nursery usually operates with the short-term goal of reducing seedling costs.

There are various reasons why low seed efficiencies may result when the nursery is operated with the short-term goal of keeping the nursery budget low. For example, upgrading of equipment is normally not considered. In fact, inefficient equipment usually is not replaced until it is no longer functional. Seedbed densities are kept high to minimize variable costs. Counter offers are not made when experienced nursery managers leave for jobs with higher salaries; the individual hired as the replacement may have no nursery experience and is often started at the bottom of the pay scale. It is remarkable that a nursery can maintain a seed efficiency of 66% under this type of management.

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There are a few organizations that view the nursery as an integral part of their tree improvement effort. Like tree improvement, these nurseries also operate with the goal of optimizing future wood production. Therefore, special care is provided to the best genetic sources so that the optimal seed efficiency can be achieved. The administrators place a high priority on obtaining a high average seed efficiency (i.e. > 85%). Therefore, the nursery managers are provided economic incentives to be efficient with seed. Although costs are still of concern, the administration provides a nursery budget that is adequate for maintaining high seed efficiency.

Administrators that place a high value on seed efficiency understand the difference between the cost of production and the present net value of the improved seed. They realize that seed cost constitutes a large proportion of seedling cost. In addition, they understand that the present net value of seed from a rogued second-generation orchard is higher than from a rogued-first generation orchard. They know that efficient nursery management can improve the economics of a tree improvement program.

The following discussion of the cost and value of improved seeds outlines some economic benefits that can be used to justify increasing seed efficiency at the nursery level. To fully comprehend the importance of high seed efficiency, it is necessary to understand the difference between the cost of improved seed and the value of improved seed.

COST OF PRODUCING IMPROVED SEED

Roughly three-fifths of the cost of seed orchard seed represents efforts in tree improvement while about two-fifths are due to seed collection and extraction (Table 1). Individuals that claim their cost for improved seed is only about 0.2 cent per full live seed (FLS) are not including the cost of selection, orchard management, progeny testing, geneticist salaries, and overhead.

Table 1. -- Estimated costs and value of loblolly pine seed from different stages of tree imporovment program.

	Woods run	Rogued first generation	Rogued second generation	Rogued third generation
	cents/full live seed			
cost of harvest and extraction	0.1	0.2	0.2	0.2
cost of harvest, extraction and tree improvement	0.1	0.5	0.5	0.5
Market value	0.125	0.3	0.55	
present net value of additional wood production*		3.0	5.5	7.5

* as compared to woods run seed

Productivity of the seed orchard greatly affects the cost of seed production (Talbert et al. 1985). For seed yields above 40 pounds per acre, net investment cost is about 0.5 cent/FLS (Table 2). The cost of producing second-and third-cycle orchard seed will likely not be much greater than 0.5 cent/FLS.

Table 2. -- Seed cost per thousand plantable loblolly pine seedlings by seed orchard yield and nursery seed efficiency.

Orchard yield	Net investment (cost/FLS)	Seed efficiency 60%	66%	75%	83%	90%	95%
(lb/A)	(cents)	Seed cost per thousand seedlings ($)					
10	1.51	25.17	22.88	20.13	18.19	16.77	15.89
20	0.83	13.83	12.57	11.07	10.00	9.22	8.74
30	0.64	10.66	9.70	8.53	7.71	7.11	6.74
40	0.53	8.83	8.03	7.07	6.39	5.89	5.58
75	0.47	7.83	7.12	6.27	5.66	5.22	4.95

Many organizations produce more seed than they need and sell the excess. Current market prices for improved loblolly pine seed usually range from 0.3 to 0.6 cent/FLS. Because of the current buyers market, the market price can be lower than the cost of production. Therefore, when using the correct provenance, purchasing rogued, first-generation seeds on the open market can be a real bargain when compared to the estimated present net value of the seed.

SEED EFFICIENCY AFFECTS SEEDLING COST

The average price of first-generation bare-root seedlings is currently close to $30/M (Table 3). Seed can be the largest single expense for producing improved seedlings (Mills and South 1984). At some nurseries, seed cost will exceed one-third of the production costs. However, some organizations subsidize the cost of tree improvement and therefore only charge the nursery for cost of harvesting and extraction. As a result, the cost of first-generation seed charged to the nursery account may be less than 0.3 cent per PLS. This allows little economic incentive for the nursery manager to be more efficient with improved seed. As a result, for some organizations, there will be little difference between the price of regular and improved seedlings. However, other organizations do not subsidize the cost of tree improvement. The nursery might be charged 0.47 cent/FLS for first generation seed (Table 2). For this reason, the cost of seed per thousand plantable seedlings (M) will depend in part on whether or not the cost of tree improvement is subsidized. When the total costs of tree improvement are charged against the nursery budget, seed cost can range from $5 to $12/M (Table 2). However, when tree improvement costs are subsidized, (only harvesting and extraction costs are charged to the nursery), seed cost may vary from only $2 to $4/M.

Although, the price difference between first- and second-generation seedlings can range from $4 to $8/M (Table 3), this difference is likely due to differences in perceived gains (i.e. difference in present net value) rather than to a difference in cost of production.

Table 3. -- 1989 cost of loblolly pine seedlings from selected sources. (State prices from Anonymous (1989))

Source	Regular	First generation	Second generation	Difference
	cost per thousand seedlings ($)			
Alabama		27.50		
Arkansas		30		
Florida		24		
Georgia		26-30		
Kentucky		40		
Louisiana		30		
Mississippi	23	31		8
North Carolina		30		
Oklahoma		30		
South Carolina		24		
Tennessee		28		
Texas		28		
Virginia		28		
Company x		33	40	7
Company y		34	38	4
Company z		28	36	8
Average		29.59	38	

The cost of producing improved seed can provide some incentive for nursery managers to keep seed efficiency high. For example, if a nursery producing 30 million seedlings has a nursery seed efficiency of 70% and seed cost of 0.5 cent/FLS, $19,500 annually could be saved by increasing the nursery efficiency to 77%. Put another way, the nursery manager could justify spending up to $19,500/yr on management practices to increase seed efficiency. However, this incentive does not exist if seeds are furnished to the nursery free of cost.

SEED EFFICIENCY AFFECTS THE PROFITABILITY OF TREE IMPROVEMENT

The profitability of a tree improvement program corresponds directly to seedlings yields from the nursery. When more seedlings are produced from improved seeds, more acres can be planted with improved seedlings. Therefore, practices that affect nursery seed efficiency directly affect the goals of tree improvement. Since nursery seed efficiency may range from 41 to 92% (Tables 4 and 5), the nursery manager will have a great impact on the present net value of the improved seed. The present net value of improved seed will be 52% greater at a nursery with 92% seed efficiency than at a nursery with only 60% seed efficiency (Table 4). However, the importance of high seed efficiency is often overlook because some individuals do not fully understand the concept of present net value.

The present net value of improved seed is based on the discounted value of the extra wood produced at the end of the rotation, minus the cost of production. The estimated present net value of improved seed can be about ten times the market value (Table 1). Since the cost of production of seed from seed orchards should be about the same regardless of generation cycle, the present net value of the seed will be the primary reason why the nursery manager should be more efficient with second generation seed than with first generation seed.

Table 4. -- Seed efficiency for small plots at seven nurseries in 1984 (From South and Larsen 1985).

Ownership	Date sown	Total density	Plantable seedling density	Culls	Seed efficiency*	Seed cost#	Present net value of 10,000 seeds**
		--#/sq.	ft.--			$/M	$
State	4/25	29.2	27.8	5	92	5.43	276
Industry	4/23	27.9	21.7	22	72	6.96	215
Industry	4/23	27.9	21.0	25	69	7.19	208
State	4/19	24.9	20.6	17	68	7.33	205
State	4/19	23.6	19.0	20	62	7.94	189
State	4/20	21.8	18.2	16	60	8.29	181
State	5/17	17.6	12.6	28	41	11.98	125

* 30.2 full live seed sown per square foot
\# A cost of 0.5 cent per full live seed
** Assuming a present net value of 3 cents per plantable seedling

The following formula can be used to calculate the increase in present value obtained by increasing seed efficiency (South 1987). This formula can be used even when an organization has a limited or an excess supply of improved seeds.

PV (PSN/PSO) X (NSE/OSE)-1 X PV1C X RA X BGR X (VGHS - VGLS)

where PV = present value of additional wood obtained by increasing the seed efficiency on one acre of improved seedlings in the nursery
PSN = number of plantable seedling produced per nursery acre
PSO – number of plantable seedling outplanted per acre
OSE = old seed efficiency (expressed as a decimal value)
NSE = new seed efficiency (expressed as a decimal value)
PV1C – present value of 1 cord of wood harvested at the rotation age
RA = rotation age
BGR = base growth rate in cords/acre/year for unimproved seedlings
VGHS = average volume gain of higher performing seedlings (at rotation age)
VGLS – average volume gain of lower performing seedlings

For example, a nursery produces 700,000 plantable seedlings per acre with a nursery seed efficiency of 70%. Seedlings are grown on 30 acres, of which 20 acres are with second-generation seed from a rogued orchard and 10 acres are with seed from a first-generation orchard. The company outplants 550 trees per acre, on a 25-year rotation, and plants on land that produces 1.5 cords/ac/yr (unimproved basis). The company's economist uses a 6% real interest rate and predicts that stumpage values in 25 years will be $20/cord. The estimated volume gains at harvest from first- and second-generation selections are 12% and 22%, respectively. The nursery manager uses the following formula to determine how much increase in present value would occur if seed efficiency was increase from 70% to 80%.

PV = $3,177 - (700,000/550) X ((0.8/0.7)-1) X $4.66 X 25 X 1.5 X (.22-.12)

Under these conditions, increasing the seed efficiency from 0.70 to 0.80 would increase the present value by $3,177 for each acre sown with second-generation seed. This means that for 20 acres of second-generation seedlings, the nursery manager could improve the "predicted genetic gain" from the nursery by $63,540. Therefore, increasing seed efficiency in the nursery can be an effective way to increase the value resulting from tree improvement.

Table 5. Selected responses from a 1990 questionnaire sent to nursery managers who produce bare-root loblolly pine seedlings.

genetics	Seed/ pound	Seed Germination	Seed efficiency	Seed cost pound	/PLS	/M	/M*
	#	%	%	$	cent	$	%
regular	18,500	78	78	18	.125	1.60	7
regular	23,080	88	89	25	.123	1.38	6
1st gen	13,902	87	52	13	.111	2.15	7
1st gen	13,900	94	88	21	.161	1.83	7
1st gen	15,199	89	74	28	.207	2.80	10
1st gen	13,700	95	86	30	.231	2.68	9
1st gen	16,097	92	55	35	.236	4.29	15
1st gen	17,311	83	83	36	.250	3.01	11
1st gen	15,250	96	80	40	.273	3.41	11
1st gen	16,400	86	82	40	.284	3.46	6
1st gen	18,046	90	70	50	.308	4.40	16
1st gen	12,378	89	79	34	.309	3.91	12
1st gen	13,174	88	68	38	.328	4.82	17
1st gen	14,000	92	89	45	.349	3.92	16
1st gen	13,621	93	81	50	.395	4.88	20
1st gen	16,500	93	87	75	.488	5.62	18
2nd gen	16,200	99	79	40	.249	3.15	11
2nd gen	14,000	95	87	30	.225	2.58	NOT SOLD
2nd gen	15,000	93	80				SEEDLINGS NOT SOLD
2nd gen	12,858	97	64				SEEDLINGS NOT SOLD

* Seed cost expressed as a percentage of seedling price.

A NEED FOR INCENTIVES

Currently, many nursery managers have little incentive to culture second-generation seedlings any differently than first-generation (or even woods run) seedlings. The nursery manager has plenty of problems to worry about besides treating seedlings differently according to their perceived
3 value. [In fact, in certain areas, early height growth of unimproved seedlings (grown from seed from Livingston Parish, LA) can exceed that of genetically improved seedlings from local seed orchards (McKeand et al. 1989)]. However, nursery managers might be more efficient with the second-generation seed if they could charge more for the seedlings. In fact, some organizations do charge $4 to $8/M more for second-generation seedlings (Table 3). This allows the nursery manager to generate more income by being more efficient with second generation seedlings.

However, many managers of company nurseries do not sell their second-generation seedlings (Table 5), and managers of state nurseries often do not sell seedlings for more than the cost of production. In addition, most State Foresters and Corporate Executive Officers do not provide the nursery manager with either incentives or adequate funding for improving seed efficiency. As a result, nursery managers have little incentive to be more efficient with seed that has a high present net value.

In fact, since some organizations place emphasis on keeping the nursery manager's salary low, they may actually select for managers with low seed efficiency. For example, take the case of an experienced nursery manager who has consistently obtained a seed efficiency of 80% and has been offered another job that pays $35,000/yr. The manager's supervisor is not allowed to match the offer and therefore has to search for a replacement at a starting salary of $25,000/yr. The individual hired has no previous nursery experience and therefore only obtains 60% seed efficiency. As a result, the nursery spends an additional $83,000/yr in seed costs (assuming a 40 million nursery and seed cost of 0.5 cent/FLS). The organization ends up spending eight times the amount required to keep the experienced manager from leaving.

To attain higher seed efficiency, State Foresters and Corporate Executive Officers should provide the nursery with adequate funding and should provide the managers with adequate incentives. Without incentives and financial support, some nursery managers have to use essentially the same equipment and practices that were employed for seed collected in the woods. This can result in wasting a third or more of the improved genetic resource.

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