Some economic aspects of sowing

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Topics

- Economic thresholds
- Economics of seed efficiency
- Sowing density and seedling cost
- Cover-crop rotation related to seedbed density and nursery income

- Economic injury level

- The economic injury level for a pesticide treatment is equivalent to the “breakeven point” at which the treatment cost equals the reduction in crop value due to pest injury.

- Action threshold

- The “economic threshold” level is the point where the pesticide treatment is applied before the economic injury level is reached (Tainter and Baker 1996).
- This is sometimes referred to as the “action threshold” and can be expressed either in terms of the pest population level or as a percentage of the crop value.

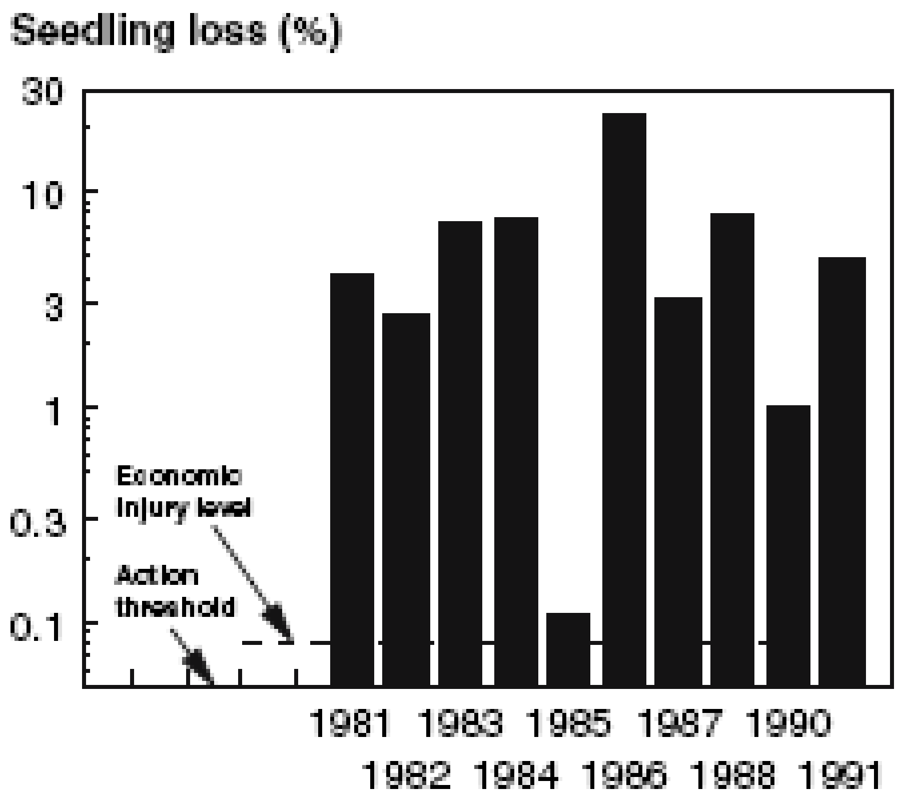

Figure 1. Seedling loss in control plots due to infection from fusiform rust (adapted from Carey and Kelley 1993). The economic injury level is 0.08% for a foliar application of triadimefon and the associated action threshold is 0% seedling loss.

Table 1. Economic injury level and economic threshold level for various IPM treatments in southern pine nurseries (assuming a value of 5 cents per seedling).

Treatment	Application	Cost per ha	Economic injury level # seedlings (% crop loss)	Economic threshold level
Prophylactic				
Methyl bromide/ chloropicrin	Soil fumigation	$3700	74,000 (5.5)	Zero
Triadimefon	Seed treatment	$5	100 (0.0075)	Zero
Thiram	Seed treatment	$10	200 (0.015)	Zero
Oxyfluorfen	Preemergence	$90	1800 (0.135)	Zero
Triadimefon	Foliar spray	$55	1100 (0.0825)	Zero
Oxyfluorfen	After crop emergence	$27	540 (0.0405)	Zero
Reactive				
Handweeding	After weed emergence	$100	2000 (0.15)	3 h of weeds/ha
sethoxydim	After grass emergence	$27	540 (0.0405)	1 h of weeds/ha
glyphosate	After nutsedge emergence	$40	800 (0.03)	20 nutsedge plants per ha
Bacillus thuringiensi	After emergence of sawflies	$40	800 (0.03)	600 defoliated seedlings per ha
fenoxycarb	After emergence of mounds	$40	800 (0.03)	1 mound
esfenvalerate	After *Lygus* emergence	$22	440 (0.033)	1 insect

Why listening to a statistician HAS cost the nursery $$$

Table 2. Results from 5 nursery studies where the IPM treatment did not result in a significant ($\alpha = 0.05$) increase in the production of plantable loblolly pine seedlings. The cost of the IPM treatment was $100/ha and the benefit/cost ratio of the treatment ranged from 14 to 68.

Study	Number of plantable seedlings/m^2 without treatment	Observed increase in plantable seedlings/m^2 due to IPM treatment	Least Significant Difference ($\alpha = 0.05$)	Percentage increase required to be statistically significant	Treatment *p*-value	*Post priori* power of test	Increase in crop value due to IPM treatment $/ha
1	212	8.6 (4.0%)	30.1	14.2%	0.3042	0.000	$2870
2	232	4.3 (1.8%)	23.7	10.2%	0.3788	0.132	$1435
3	192	20.5 (10.6%)	38.7	20.1%	0.6512	0.000	$6817
4	199	12.9 (6.5%)	26.9	13.5%	0.2550	0.227	$4305
5	307	10.8 (3.5%)	22.6	7.4%	0.4332	0.102	$3588

Why listening to a statistician HAS cost the nursery $$$

Year	Treatment	Seedlings/ 0.093 m^2	RCD (mm)
1996	Fumigation	26.3	4.1
	Control	25.5	3.9
	p value	0.5352	0.6198
1997	Fumigation	32.2	4.2
	Control	29.9	3.9
	p value	0.1886	0.3544
1998	Fumigation	19.1	3.4
	Control	18.1	3.1
	p value	0.0591	0.2083
1999 **no**	Fumigation	21.3	3.9
	Control	21.1	3.9
	p value	0.7943	0.4503
2000 **no**	Fumigation	22.3	4.4
	Control	23.9	4.1
	p value	0.6144	0.5926

3.1% increase in crop value

7.7%

5.5%

No increase

No increase

Why listening to a statistician HAS cost the nursery $$$

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	Control	18.1	3.1
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1999	Fumigation	21.3	3.9
no	Control	21.1	3.9
	p value	0.7943	0.4503
2000	Fumigation	22.3	4.4
no	Control	23.9	4.1
	p value	0.6144	0.5926

3.2 mm RCD = plantable
3.1 mm = cull.

If average RCD = 3.1 mm,
I assume the cull % is at least 50%?

Do researchers include culls in their
Definition of seedlings/sq foot?

Why do researchers sometimes ignore
cull % and seed efficiency?

Do they assume managers sell
Culls at the same price as plantables?

Table 3. The effect of crop value and an IPM treatment on the profit and economic injury level at five hypothetical loblolly pine nurseries. The treatment costs $100/ha and reduces the amount of diseased and cull (i.e. Grade 3) stock but has no effect on total production (each nursery produces 200 plants/m^2).

Seedling classification	Production without treatment	Production with treatment	Nursery A	Nursery B	Nursery C	Nursery D	Nursery E
	No./m^2	No./m^2	Value per plant ($)				
Cull-diseased	10	0	0.04	0	0	0	0
Cull-grade 3	30	10	0.04	0.04	0	0	0
Grade 2	100	120	0.04	0.04	0.04	0.04	0.38
Grade 1	60	70	0.04	0.04	0.04	0.05	0.38
Incentive to reduce losses due to disease			low	moderate	high	high	very high
Economic injury level (# plants/ha)			N/A	2500	2500	2244	263
Profit due to treatment ($/ha)			−$100	$2566	$8000	$8666	$75,900

Conclusion

- The amount of money you can justify to spend on new equipment or a new pesticide treatment depends on how much the boss values the seedling.

Low value= low economic justification
high value= high economic justification

How do you justify buying a new Agrilock sprayer and switching from no-mulch to spraying Agrilock?

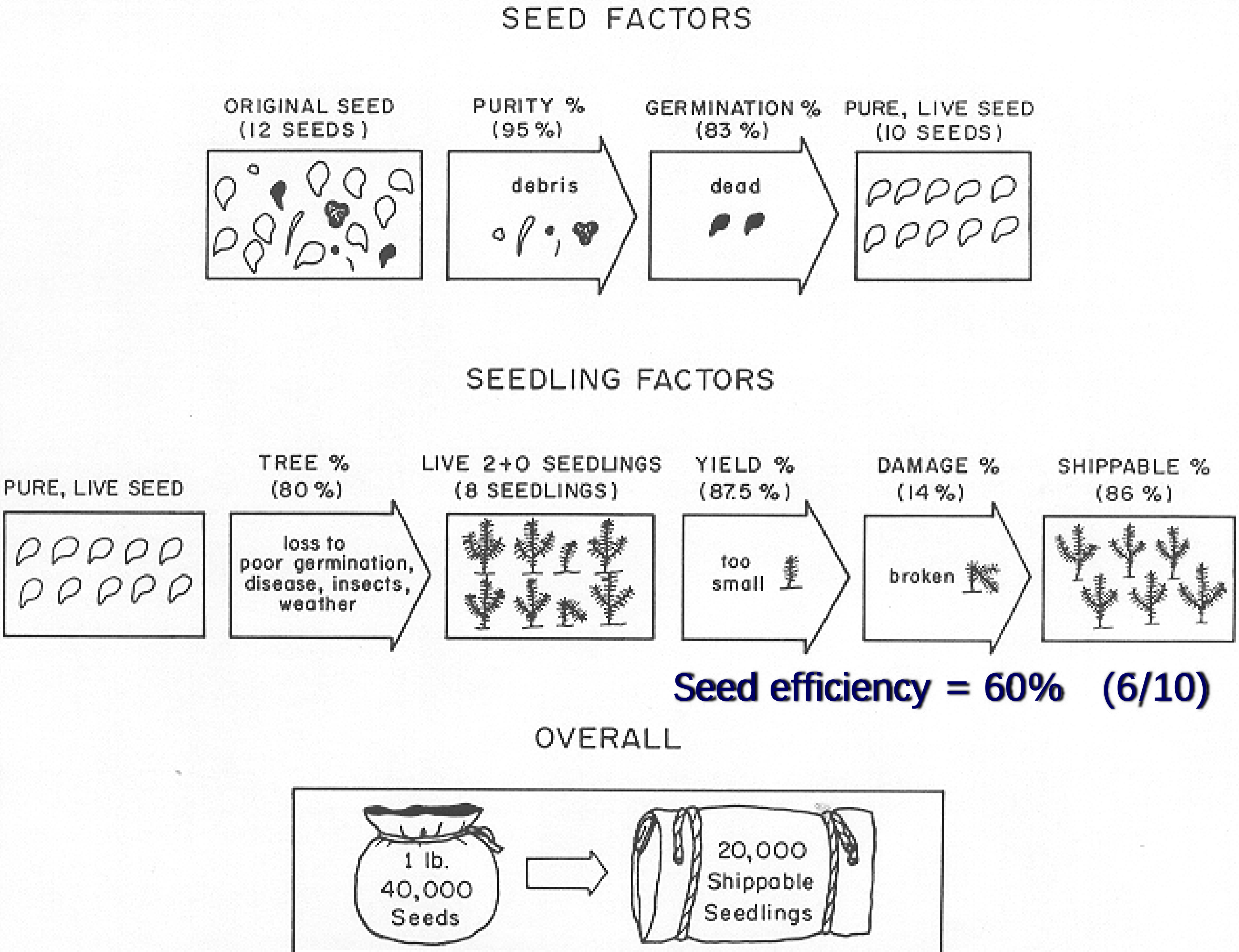
- Increase in seed efficiency
  (does not work when seed is free)
- Increase in crop value
  (does not work when extra trees are not sold)
- Increased chance of hitting production goals
  (does not work if boss thinks a heavy spring thunderstorm will not occur).

One major reason to have nurseries is to increase seed efficiency!

Seed efficiency

Definition:

plantable seedlings per pure live seed



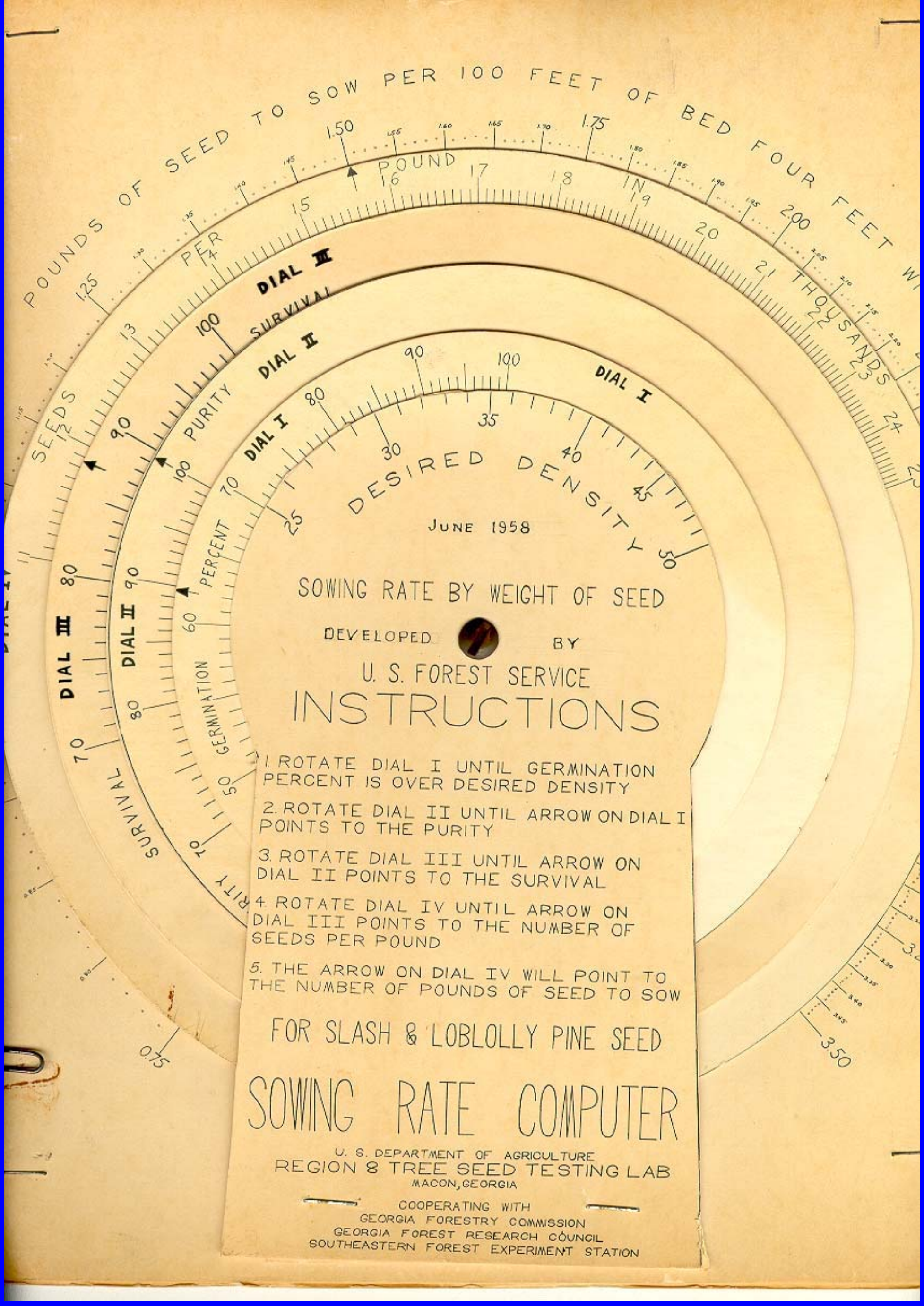
Seed efficiency = 60% (6/10)

This calculator was used too calculate
Sowing rates needed to produce
25 –50 seedlings/sq.ft.

Desired density = 25/sq.ft.
Germination % = 90%
Purity = 90%
Nursery survival factor = 90%
Seeds per pound = 13,800

How many pounds of seed per
100 feet of bed?

1 pound



One major reason to have nurseries is to increase seed efficiency!

• natural		1/20,000
• direct seeding	(untreated)	1/1,000
• direct seeding	(treated)	1/100
• Nursery	(1930)	1/3
• Nursery	(1950)	1 / 2
• Nursery	(1970)	2 / 3
• Nursery	(2001)	8 /10
• Nursery	(NZ rooted cutting)	150/1
• Nursery	(tissue culture)	20,000/1

Economic aspects of nursery seed efficiency!

D.B. South (SJAF 1987)

- Free seed (but is it really free?)
- Collection costs $20/pound
- Total costs $60/pound
- Market value $50/pound?

- Present net value (improved seed) $300/pound
- Market value (controlled crosses NZ) $2,500/pound

Estimated costs and value of loblolly pine seed from different stages of tree improvement program.

	Woods run	Rogued first generation	Rogued second generation	Rogued third generation
	---------------cents/purel 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

http://www.forestry.auburn.edu/sfnmc/pubs/manuscri/nurs_mgt/seedeff.html

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

Orchard	Net	Seed efficiency					
yield	cost/FLS)	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

http://www.forestry.auburn.edu/sfnmc/pubs/manuscri/nurs_mgt/seedeff.html

Seed Prices

2003 Average Seed Cost per Seedling for Seedling Purchase/Sale			
Symbol	**Species**	**Cents per Plantable Seedling**	
		B class	**A class**
Ba	Amabilis Fir	3.61	6.16
Bg	Grand Fir	1.67	
Bl	Subalpine Fir	2.41	
Cwr	Western Red Cedar	0.64	3.05
Fdi	Douglas-fir interior	1.57	
Fdc	Douglas-fir coastal - B class	2.24	
Fdc	Fdc - A class GW 2-6%		8.53
Fdc	Fdc - A class GW >7%		13.14
Hm	Mountain Hemlock	1.27	
Hw	Western Hemlock	0.72	3.42
Lw	Western Larch	1.66	5.12
Plc	Lodgepole Pine Coastal	0.83	
Pli	Lodgepole Pine Interior	1.09	6.01
Pw	White Pine	4.83	15.78
Py	Ponderosa Pine	3.53	
Ss	Sitka spruce	0.53	2.79
Sx	spruces	0.41	3.21
Sxs	Sitka cross	0.38	0.53
Yc	Yellow Cedar	9.92	16.98

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

	Date sown	Total density	seedling density	Culls	Seed efficiency*	Seed cost#	NPV
		--#/sq. ft.--		---- % --		$/M	$/lb
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

$$PV = (PSN/PSO) \times (NSE/OSE) - 1 \times PV1C \times RA \times BGR \times (VGHS - VGLS)$$

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.

How do you justify buying a new Agrilock sprayer and switching from no-mulch to spraying Agrilock?

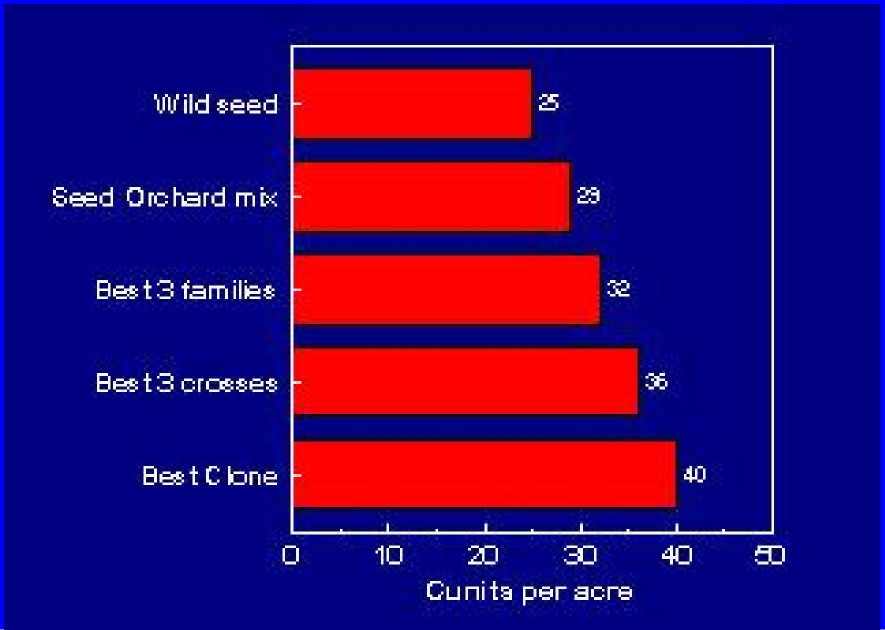
Economics of reducing culls

	1% improvement	2% improvement
18/square ft	$175/acre	$350/acre
26/square ft	$350/acre	$700/acre

For a 30 million tree nursery a 2% reduction in culls results in an additional 600,000 trees or an additional $24,000/yr (assuming 4 cents/tree)

How do you justify buying a new Agrilock sprayer and switching from no-mulch to spraying Agrilock?

BUT...for a 30 million tree nursery a 2% reduction in culls results in an additional 600,000 trees or an additional $600,000/yr (assuming the plant has a "genetic value" of 10 cents/tree)

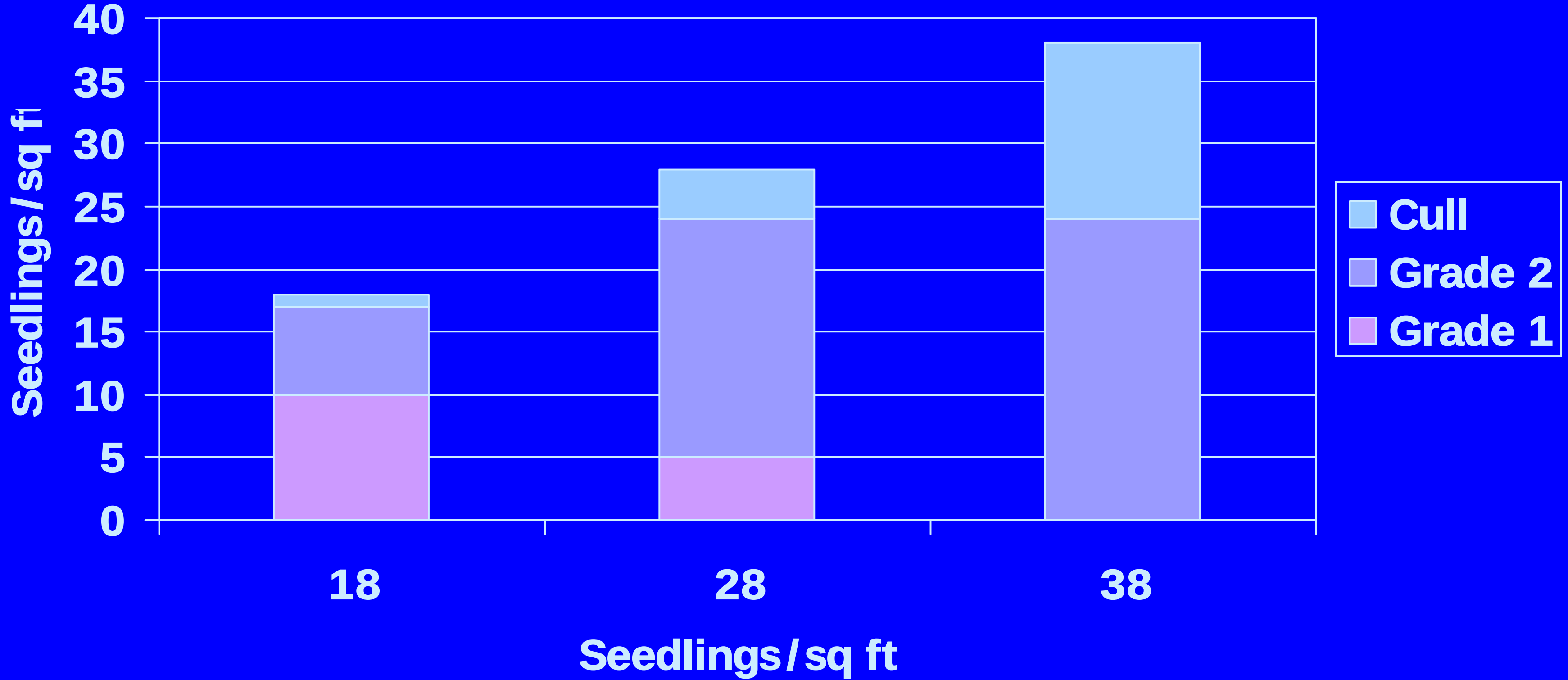


35 cents each

Topics

- Economics of seed efficiency
- Sowing density and seedling cost
- Cover-crop rotation related to seedbed density and nursery income

Which density to use?



Half the density does not mean twice the cost!

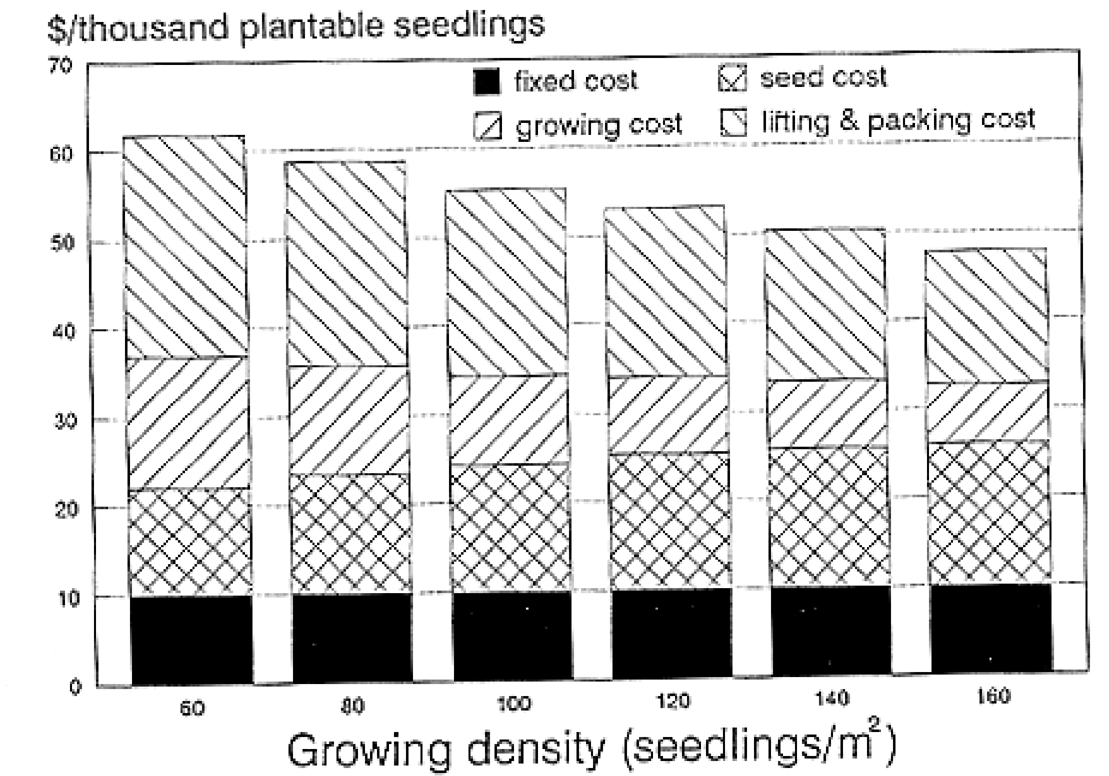
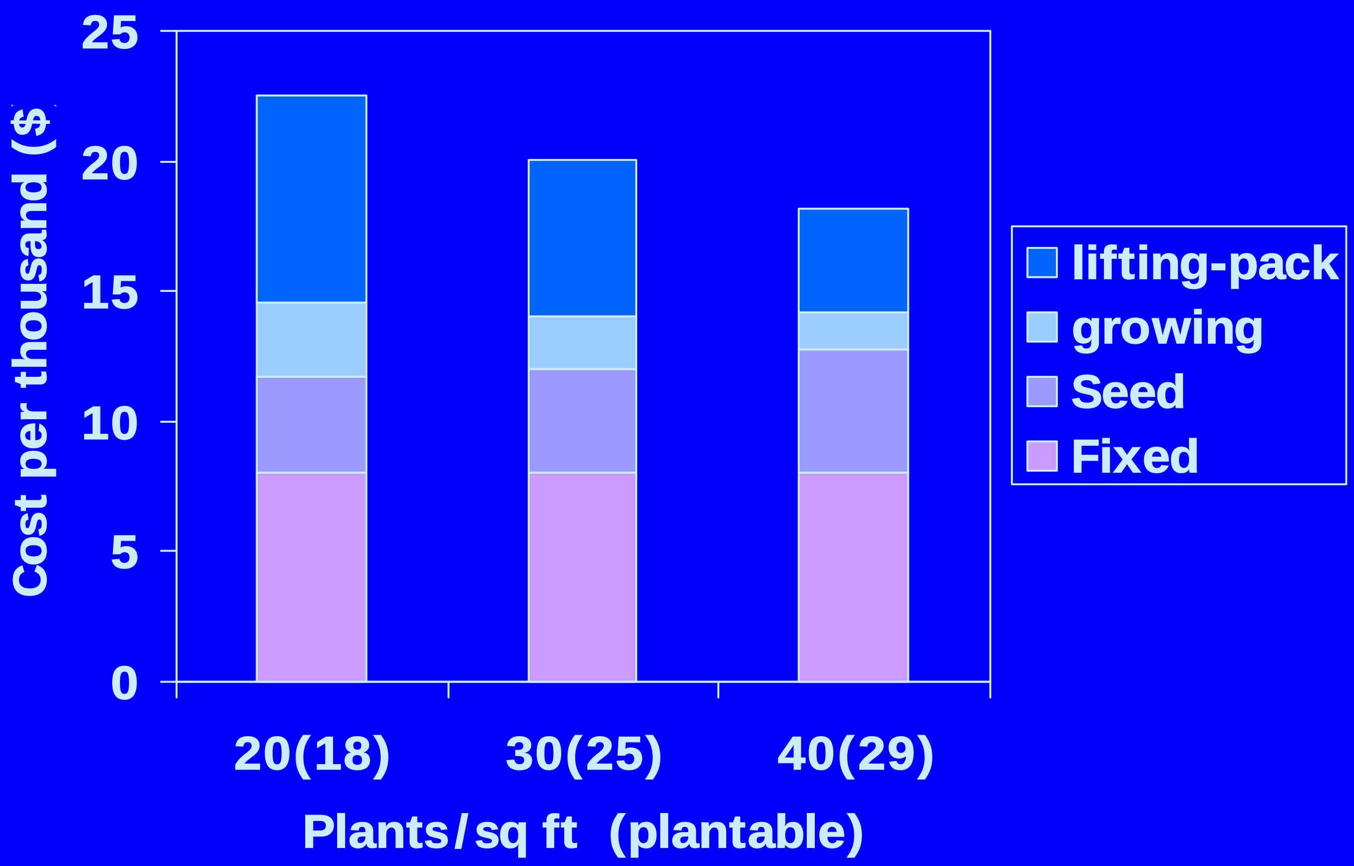


Fig. 9. An example of the effect of growing density (plantable seedlings plus culls) on cost of producing 1000 plantable *P. palustris* seedlings.

Half the density does not mean twice the cost!



Topics

- Economics of seed efficiency
- Sowing density and seedling cost
- Cover-crop rotation related to seedbed density and nursery income

What effect does sowing rate have on nursery income?

- Assume we drop densities from 26/sq ft to 20/sq ft.

- What does this 23% reduction have on seedling sales?

(assume same price per seedling)

pine pine cover crop cover crop

2:2 rotation @ 26/sq ft

pine pine cover crop

2:1 rotation at 20/sq ft

Cover crop rotation effect on seedling production

	2:2 rotation	2:1 rotation
20/square ft	10/sq ft/yr	13.3/sq ft/yr
26/square ft	13/sq ft/yr	17/sq ft/yr

Nursery income need not be reduced by lowering seedbed density

Is seed efficiency higher in container or bareroot nurseries?

Pinus contorta (Lodgepole Pine)

Cone and Seed Production Characteristics

Reproductive cycle	3 years
Cone length (cm)	3-6
Cone bearing age (collectable quantities)	15-20 years
Cones/hectolitre	8 300
Periodicity	2-4 years
Viable seeds/hectolitre of cones	
Coast	176 660
Interior	70 546
Position of cones in crown	Throughout
Ease of cone detachment	Difficult except when frozen
Plantable trees/hectolitre of cones	
Coast	
Bareroot	43 000
Container	25 000
Interior	
Bareroot	29 000
Container	21 000

What is seed efficiency
For Coastal source

Bareroot?

Container?

Pinus contorta (Lodgepole Pine)

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Bareroot	43 000
Container	25 000
Interior	
Bareroot	29 000
Container	21 000

What is seed efficiency
For Coastal source

Bareroot = 24%

Container = 14%

Seed efficiency in container nurseries (South and Young 1995)

Germ%	Seed/cell	Oversow	Seed eff.
100	1	40%	71%
95	1	45%	72%
90	2	30%	45%
85	3	40%	32%
80	4	50%	26%
75	4	60%	28%

Summary

Seed efficiency is very important
to the economics of nursery management.

As the value of seed (or plugs) increases, the justification for investing in improving seed/plant efficiency increases.

Cutting seedbed density in half does not double seedling cost.

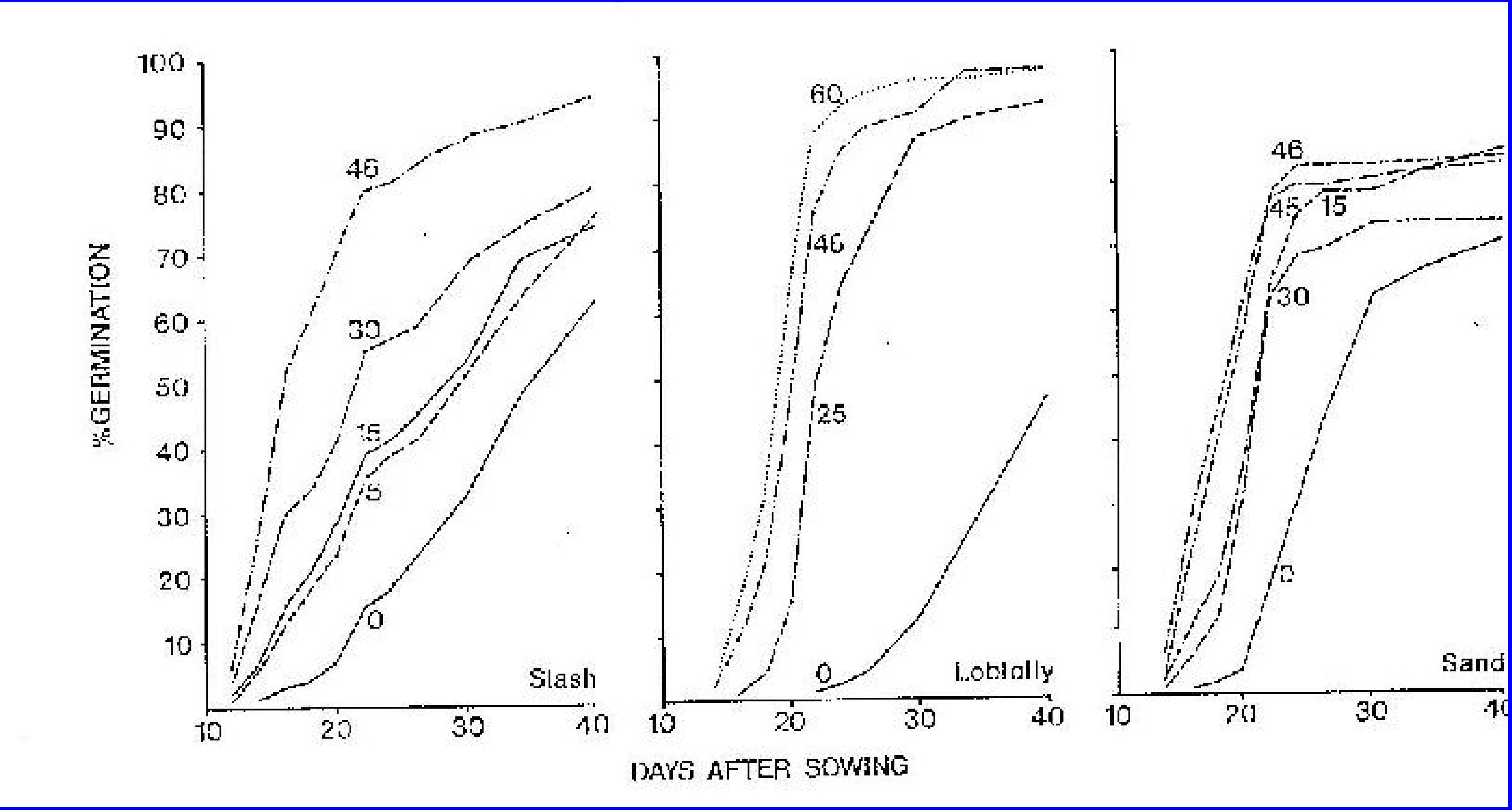
Nursery economics is affected by both
seedbed density and cover-crop rotation.

Ways to improve seed efficiency

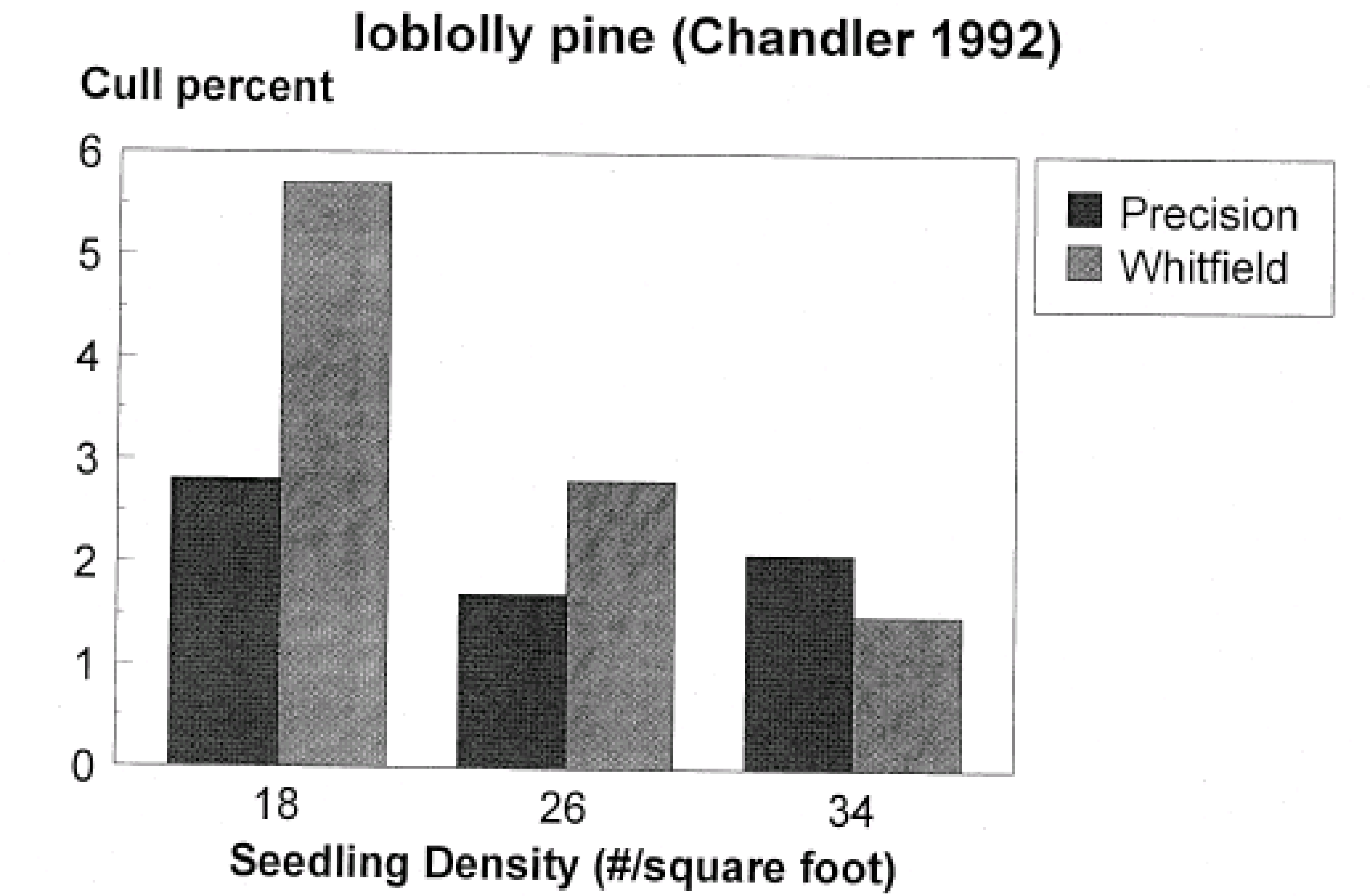
- Use good seed
- Stratify properly
- Keep soil infiltration high
- Precision sow
- Sow at low seedbed densities
- Use soil fumigation
- Use a bird repellant
- Use a soil stabilizer
- Sow at correct depth
- Treat with pesticides
- Provide adequate nutrition
- Use proper irrigation

Use good seed

Stratify seed



Precision sow


loblolly pine (Chandler 1992)
Cull percent
6
5
4
3
2
1
0
Precision
Whitfield
18
26
34
Seedling Density (#/square foot)

Sow at low densities

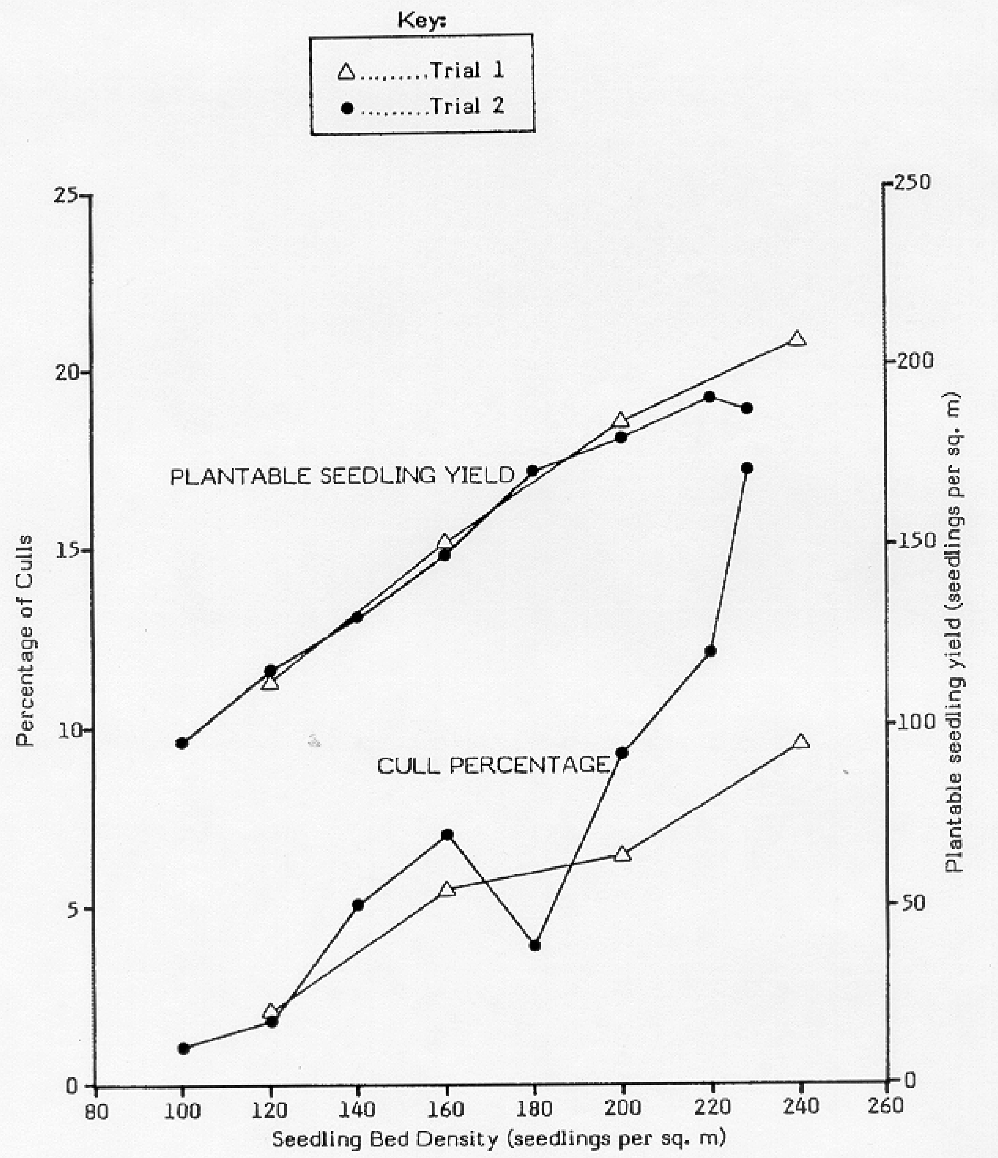
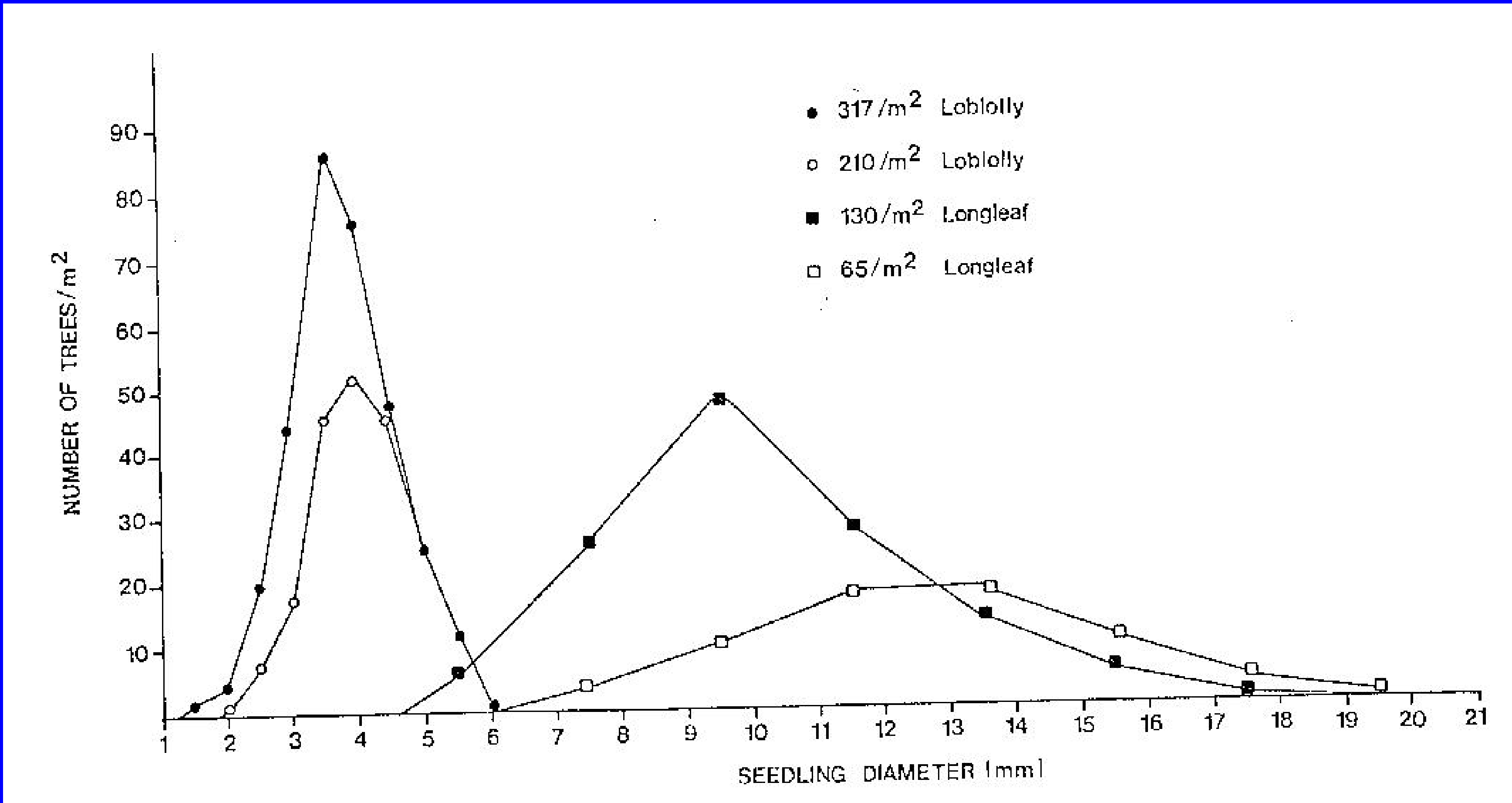
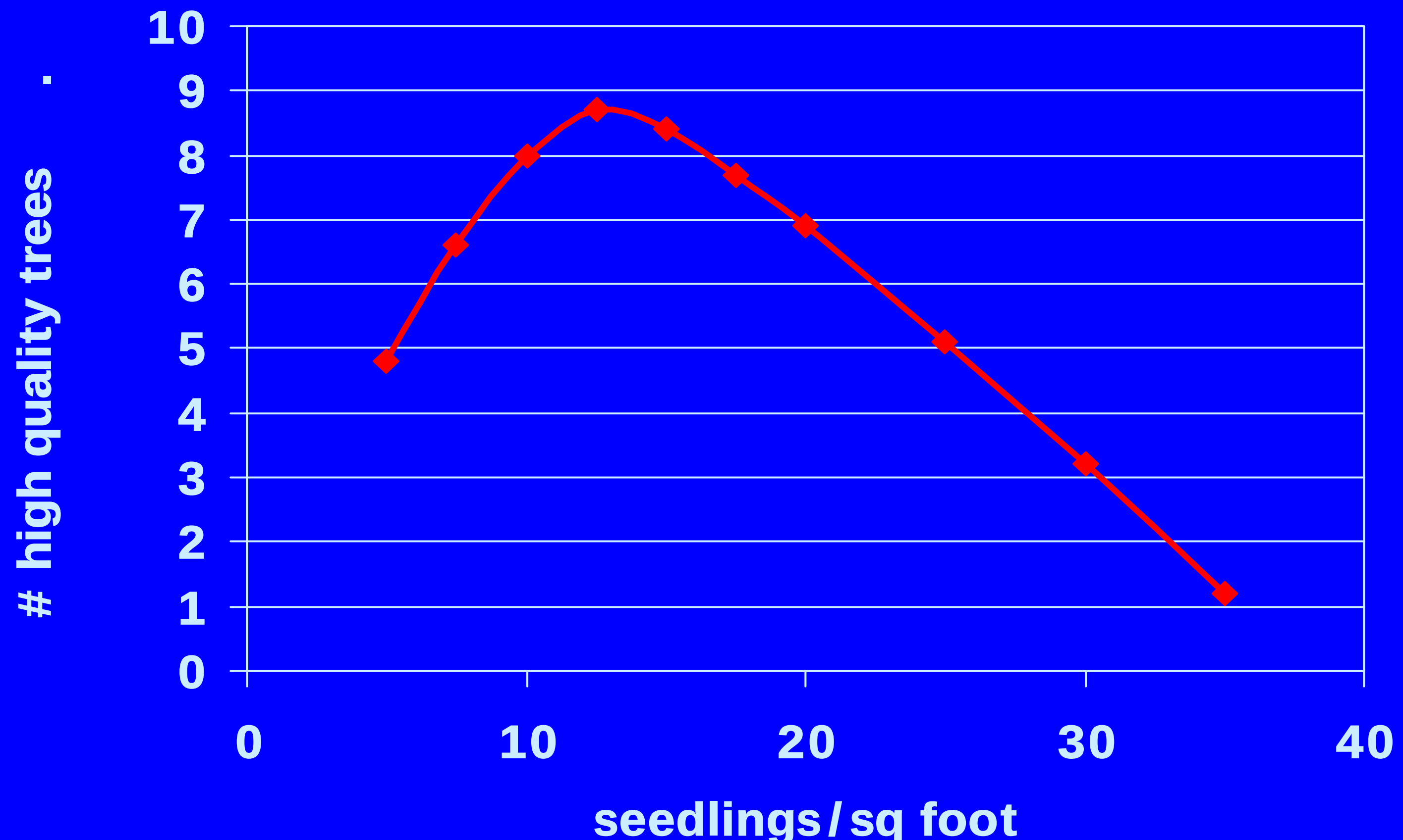


Figure 1. Cull Percentage and Plantable Seedling Yield in relation to Seedling Bed Density for Trials 1 and 2.



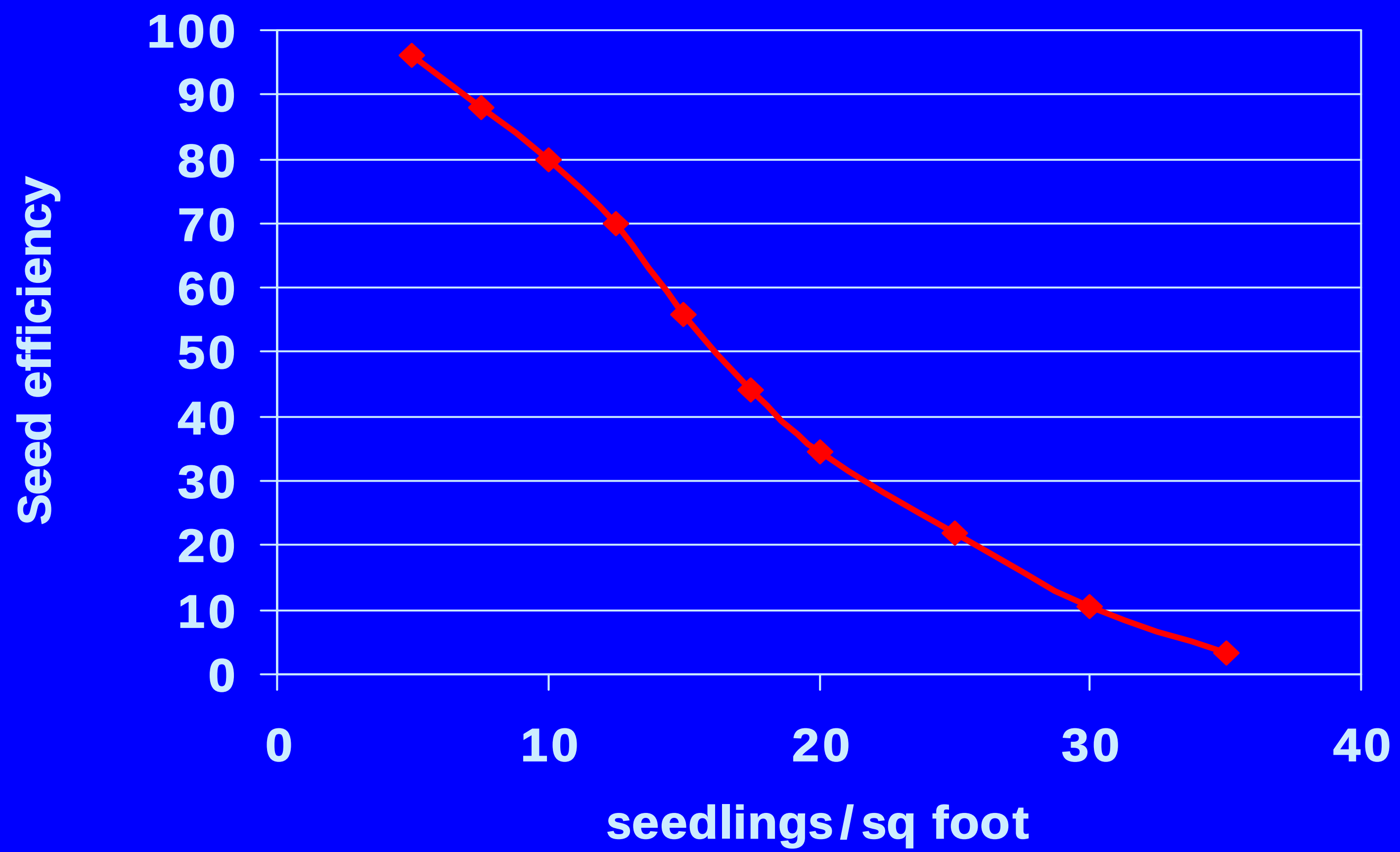
317/m2 Loblolly
210/m2 Loblolly
130/m2 Longleaf
65/m2 Longleaf
NUMBER OF TREES/m2
90
80
70
60
50
40
30
20
10
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
SEEDLING DIAMETER (mm)

High seedbed densities = low quality hardwood seedlings



Stoeckeler 1967 USFS Res. Note NC-25

High seedbed densities = low seed efficiency



Stoeckeler 1967 USFS Res. Note NC-25

Soil fumigation

Increase in seedling production with methyl bromide fumigation

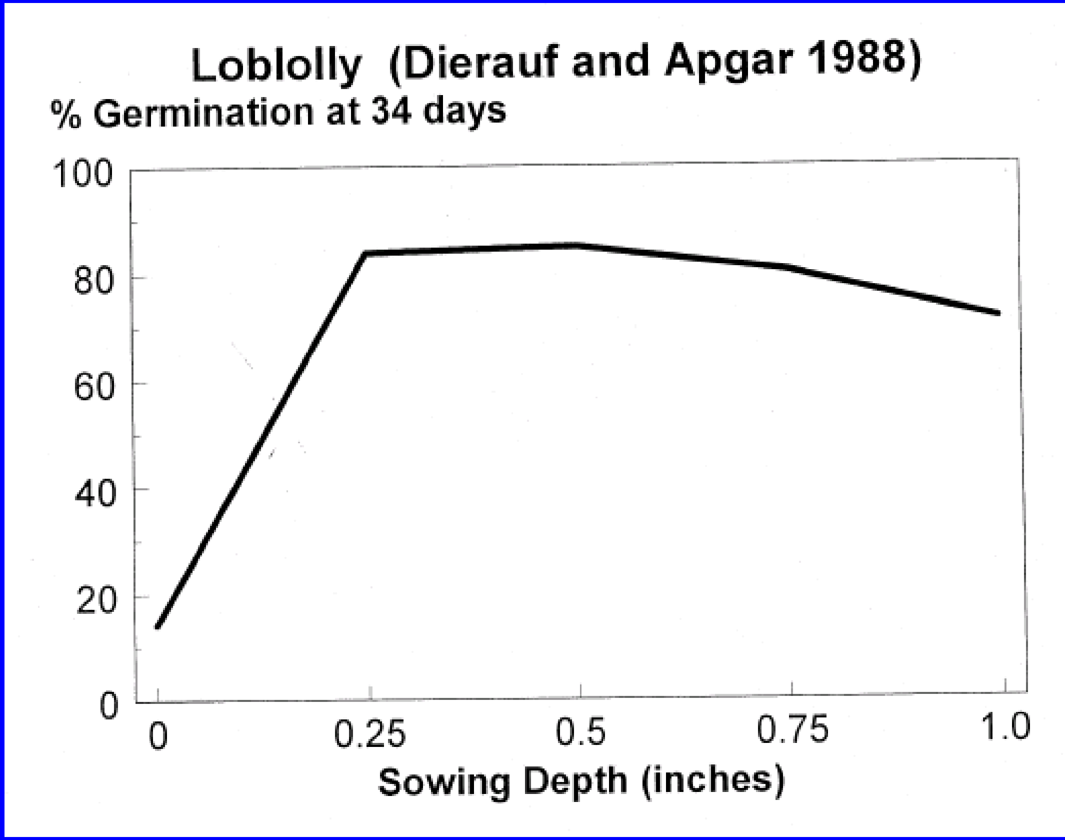
Year	Check	Methyl bromide	Gain per sq ft.	Increase in crop value
1993	16.3	20.0	3.7*	22%*
1994	20.9	22.1	1.2	5.7%
1995	24.5	25.8	1.3	5.3%
1996	17.5	19.4	1.9	10.9%
All 4 tests	20.0	21.8	1.8*	9%*

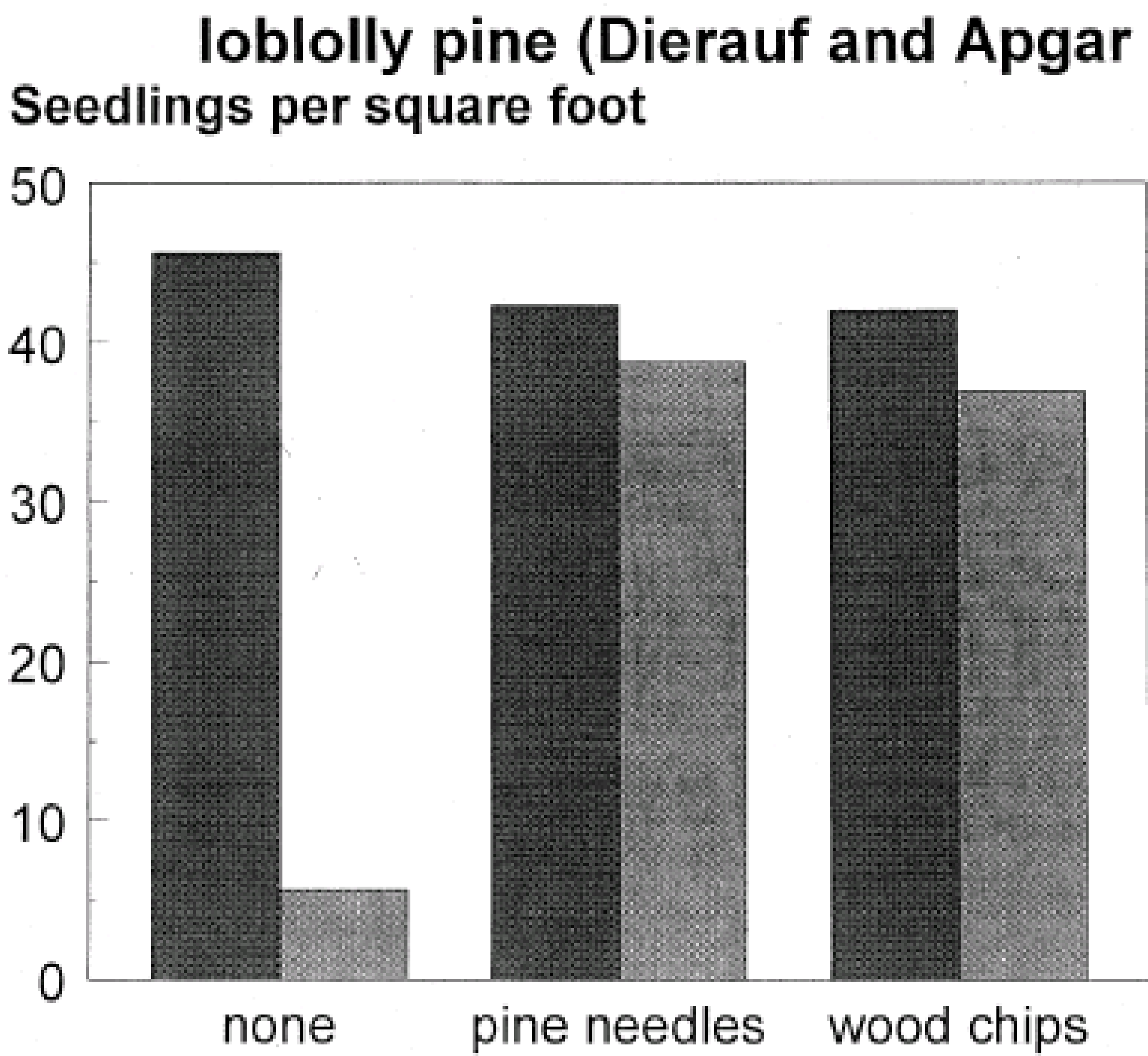
* significant at the 0.05 level of probability using contrast statements.

Use a bird repellant

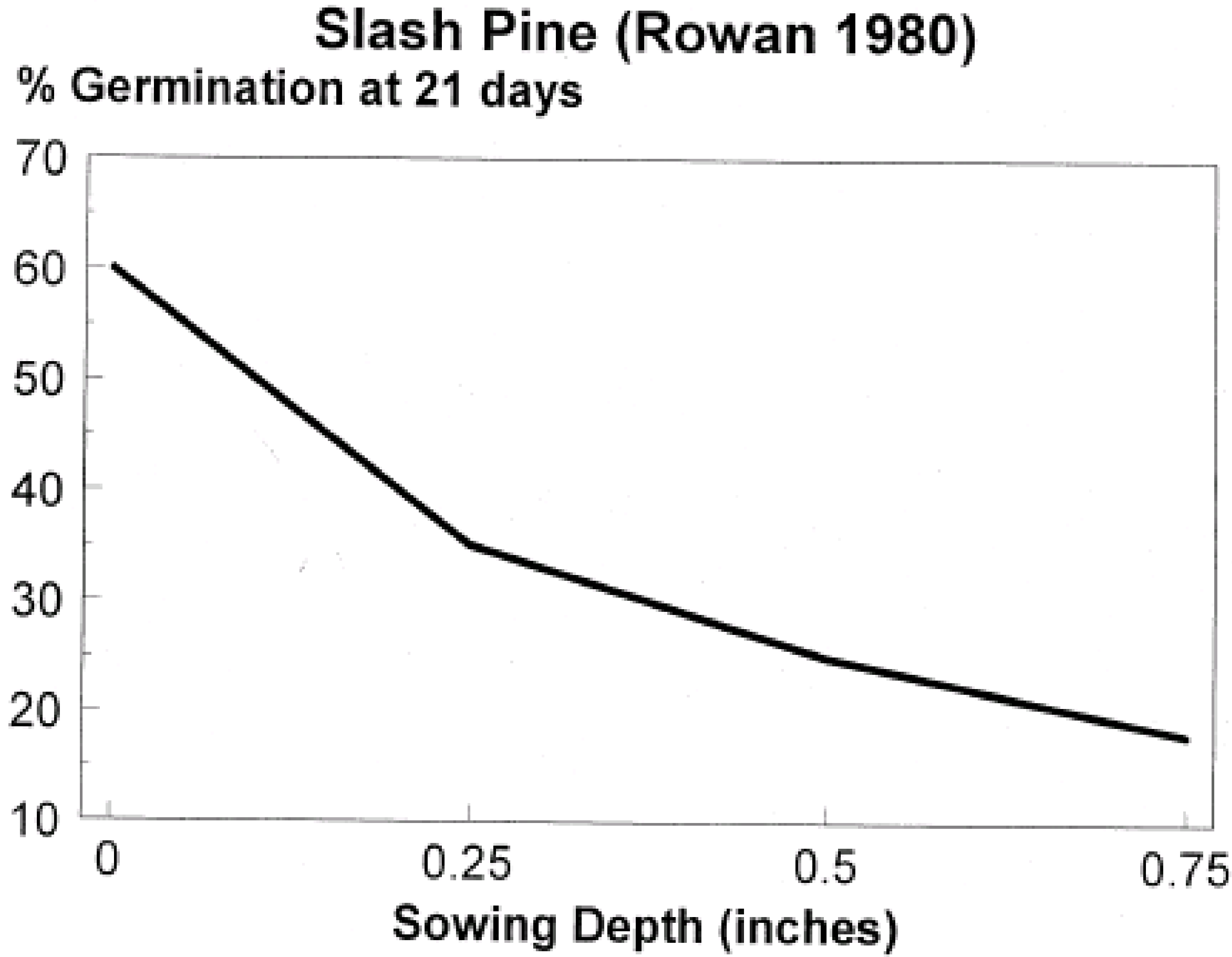
The most commonly used seed treatment chemical is thiram. This chemical is both a bird or bird and animal repellent, and a fungicide that has activity against certain seedborne and soilborne pathogens. There are presently no systemic seed treatment compounds registered for use against seed-borne pathogens. Anthraquinone (Flight Control) is also a bird Repellant.

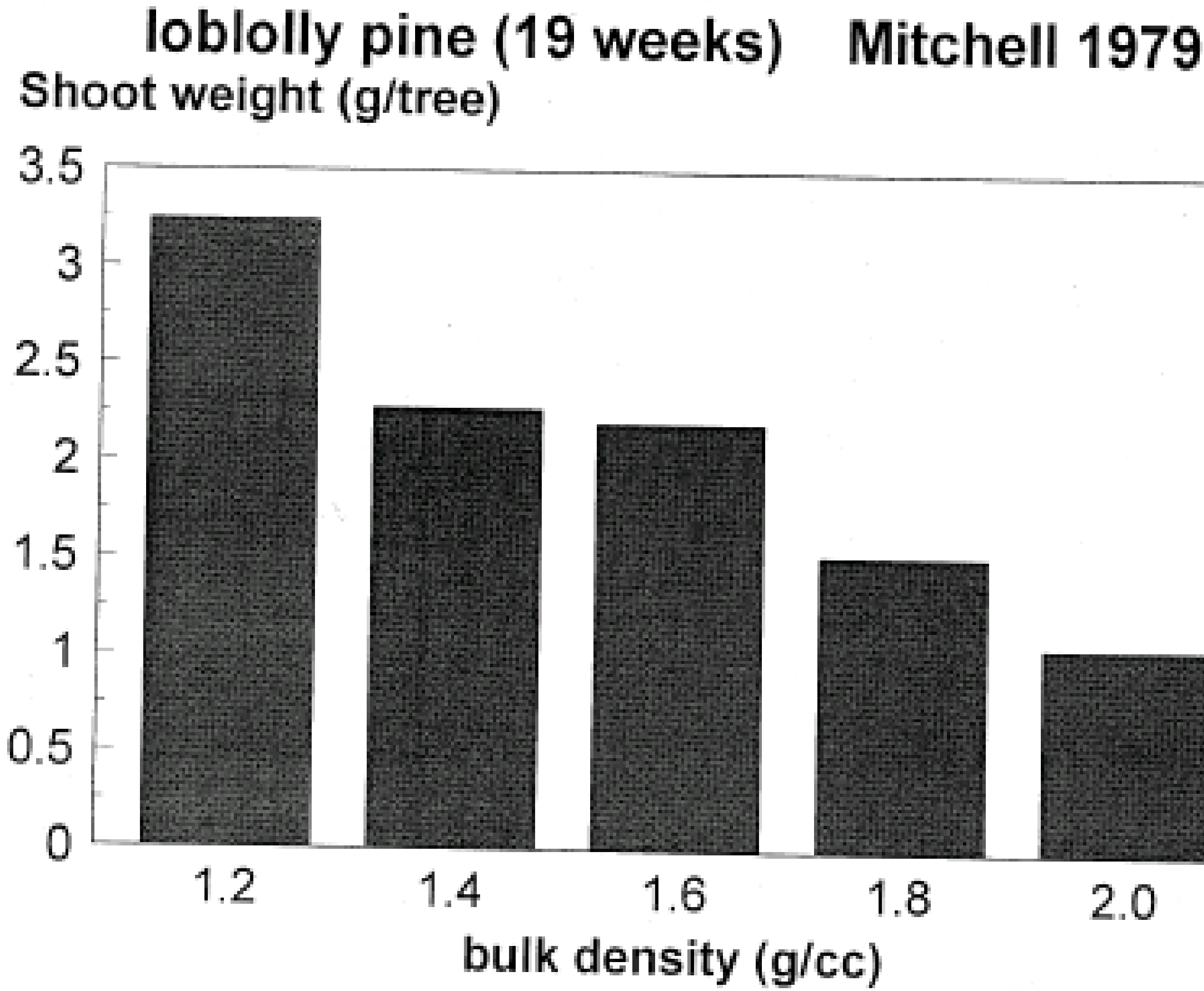
Sow at correct depth

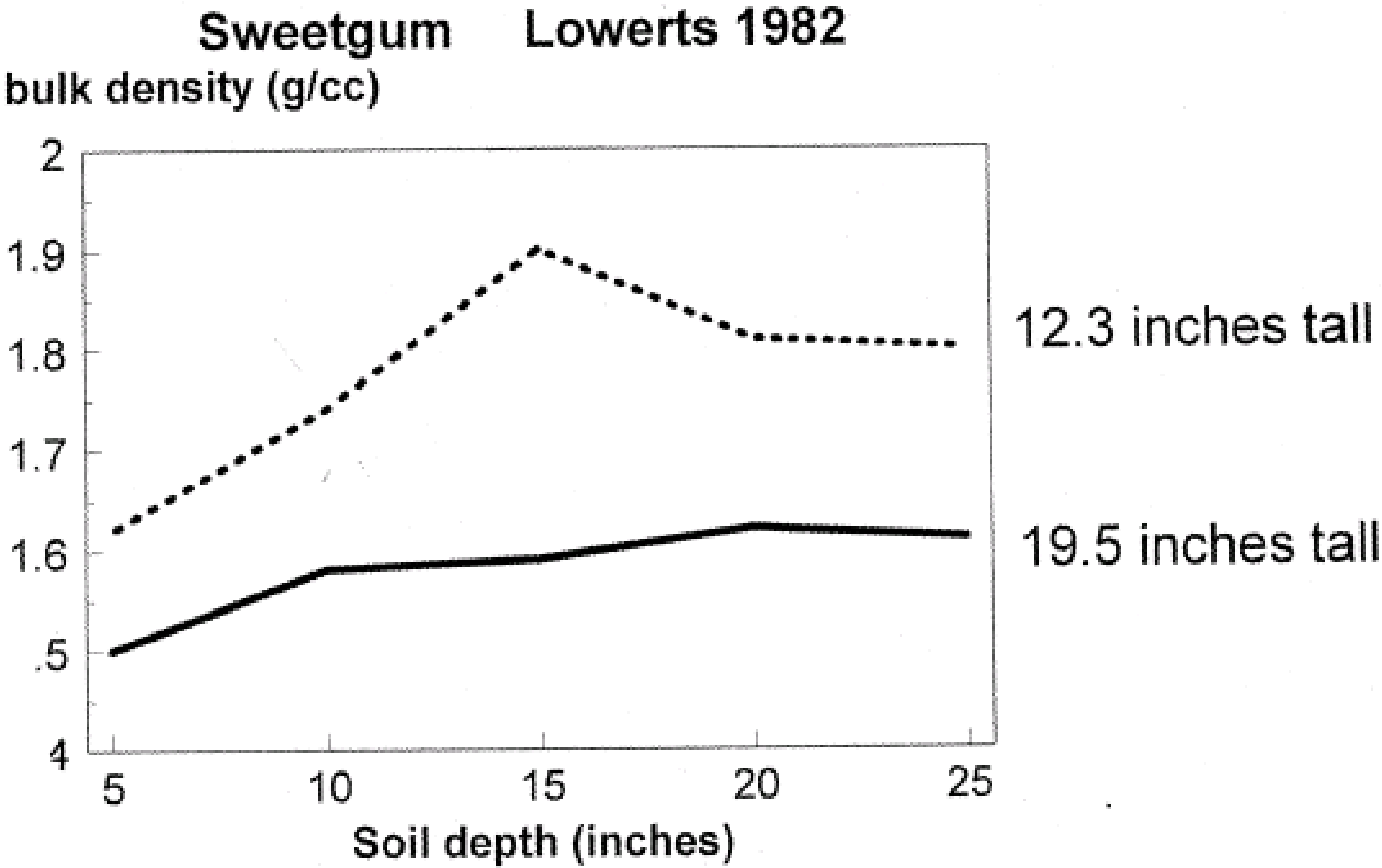


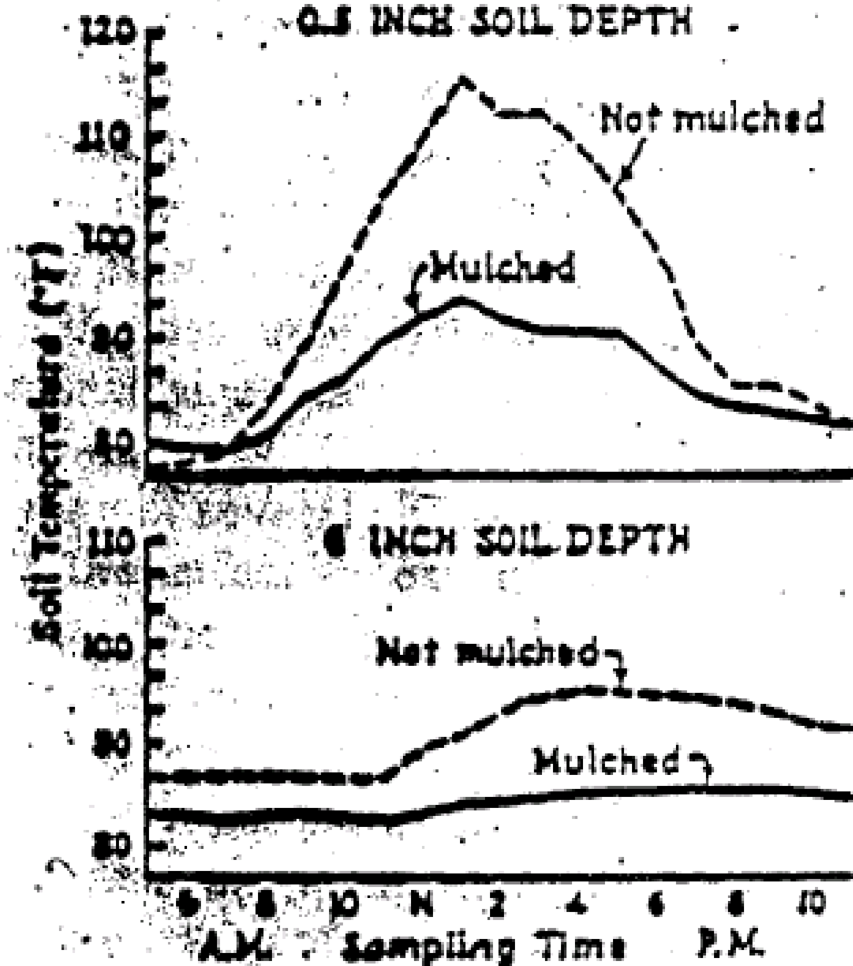


loblolly pine (Dierauf and Apgar 1989)
Seedlings per square foot
50
40
30
20
10
0
none
pine needles
wood chips
0.25-0.5
Surface

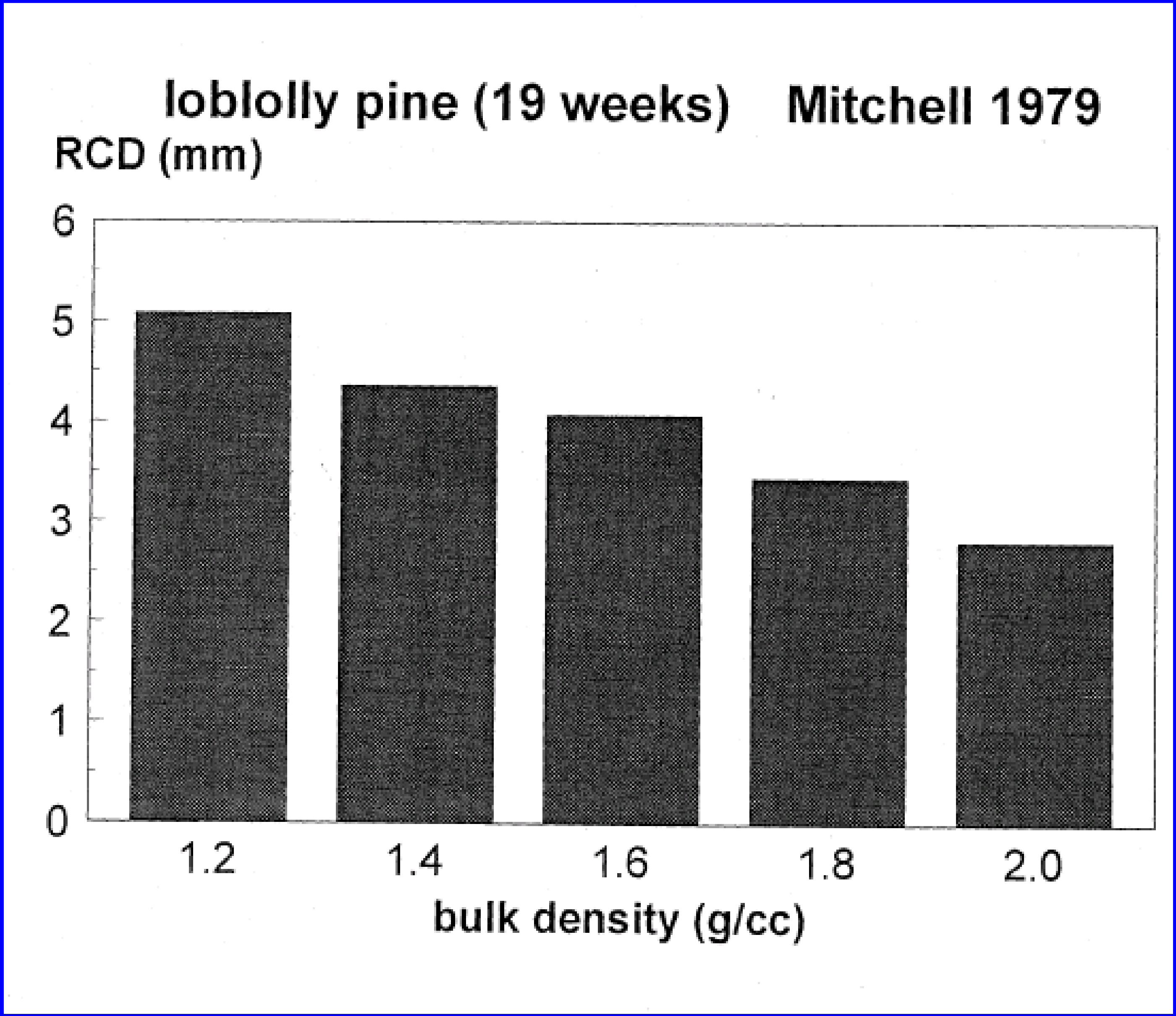

Slash Pine (Rowan 1980)
% Germination at 21 days
70
60
50
40
30
20
10
0
0.25
0.5
0.75
Sowing Depth (inches)


loblolly pine (19 weeks) Mitchell 1979
Shoot weight (g/tree)
3.5
3
2.5
2
1.5
1
0.5
0
1.2
1.4
1.6
1.8
2.0
bulk density (g/cc)


Sweetgum Lowerts 1982
bulk density (g/cc)
2
1.9
1.8
1.7
1.6
.5
4
5
10
15
20
25
Soil depth (inches)
12.3 inches tall
19.5 inches tall

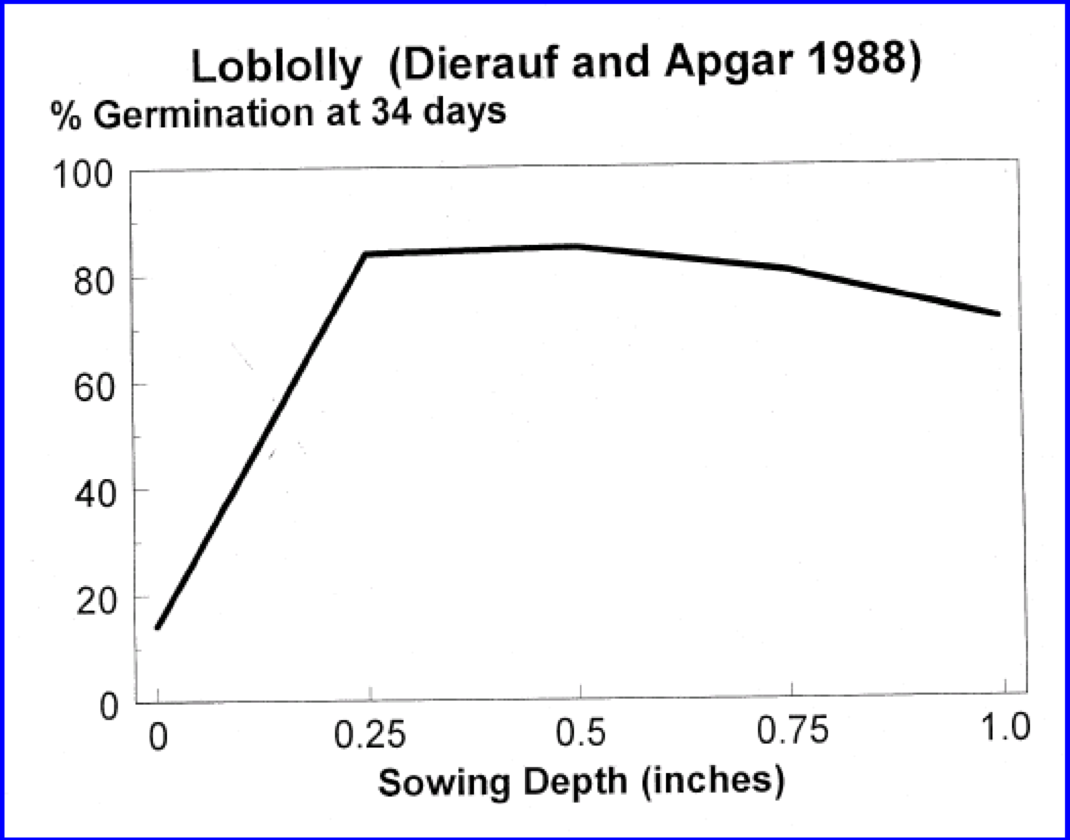


0.5 INCH SOIL DEPTH
Not mulched
Mulched
6 INCH SOIL DEPTH
Not mulched
Mulched
Soil Temperature (°F)
120
110
100
90
80
110
100
90
80
6
8
10
N
2
4
6
8
10
A.M.
Sampling Time
P.M.

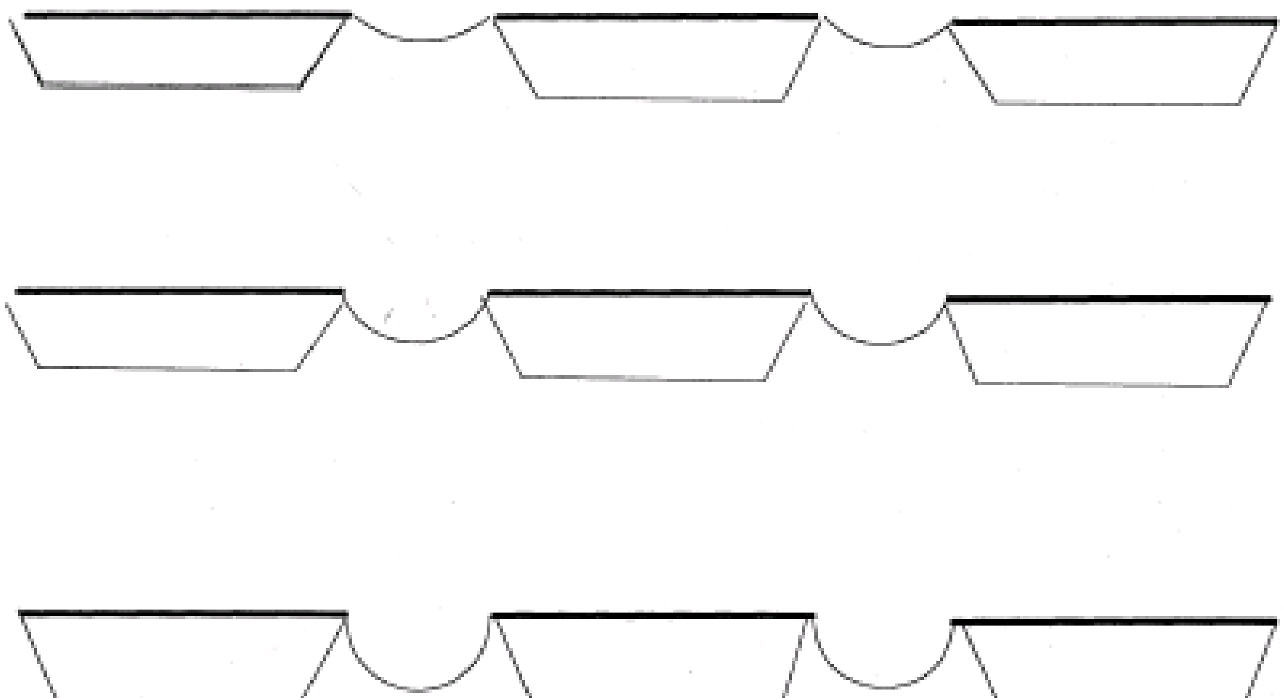

loblolly pine (19 weeks) Mitchell 1979
RCD (mm)
6
5
4
3
2
1
0
1.2
1.4
1.6
1.8
2.0
bulk density (g/cc)

Loblolly pine Mitchell 1979

Bulk Density	gleying	anaerobic
1.2	no	no
1.4	no	no
1.6	no	no
1.8	no	odor
2.0	yes	odor


Loblolly (Dierauf and Apgar 1988)
% Germination at 34 days
100
80
60
40
20
0
0
0.25
0.5
0.75
1.0
Sowing Depth (inches)

ROOTING DEPTH



Why have state nurseries lost market share?