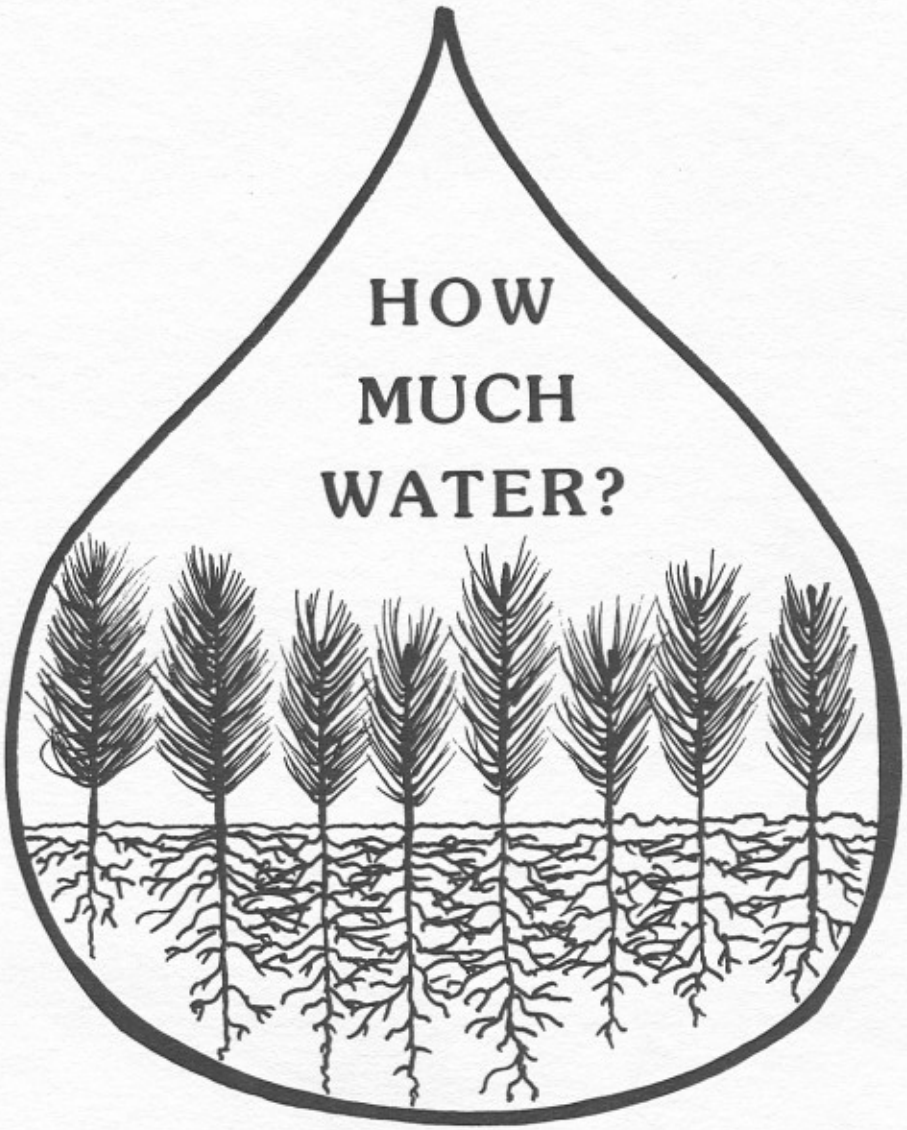
Occasional Report 93 January 1991

A THREE-YEAR LOBLOLLY PINE SEEDBED IRRIGATION STUDY



Virginia
Department of Forestry

A THREE-YEAR LOBLOLLY PINE SEEDBED IRRIGATION STUDY

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ABSTRACT

Irrigation was varied on test plots over a three-year period at two different nurseries. Soil moisture tensions of 5 to 30 centibars were tested, as well as the previous operational rate of 1 inch per week. Soils at both nurseries are more than 90 percent sand.

The drier irrigation treatments generally reduced height growth in the seedbed. They also tended to reduce diameter growth, but this influence on diameter growth was confounded by higher nitrogen status late in the season in the drier plots. The percent of cull seedlings, either too small in diameter or too short, increased with decreasing water.

After three seasons in the field, there were no large, consistent, or statistically significant differences in survival related to irrigation treatment.

INTRODUCTION

A total of six similar irrigation studies were installed in 1985, 1986, and 1987 at our New Kent and Sussex nurseries. For years, our irrigation "guide" had been an inch of water per week, either from rainfall or irrigation. In these studies, we used a "quick draw" portable tensiometer to measure soil moisture tension. We irrigated when water tension at a 2 to 3 inch soil depth reached or exceeded the treatment levels listed below. The treatments, by year, were as follows:

1985 - 1 inch per week, 8, 15, and 30 centibars
1986 - 10, 20, and 30 centibars
1987 - 5, 10, 20 and 30 centibars

We usually irrigated for about an hour, applying approximately 1/4 inch of water. For the 20, and especially the 30 centibar treatments, this was probably not enough to bring soil moisture up to field capacity down to a 6 inch depth, even though soils at both nurseries average more than 90 percent sand. Irrigation water was also applied to wash in nitrogen and herbicide applications, regardless of soil moisture tension in the irrigation plots.

SEEDBED PROCEDURES

Irrigation plots were established by disconnecting 2 adjacent risers in an irrigation line, so that no irrigation water would reach seedbed areas between the removed risers, which are 40 feet apart (Figure 1). The risers were then temporarily reconnected for any necessary irrigation, based on tensiometer readings or chemical

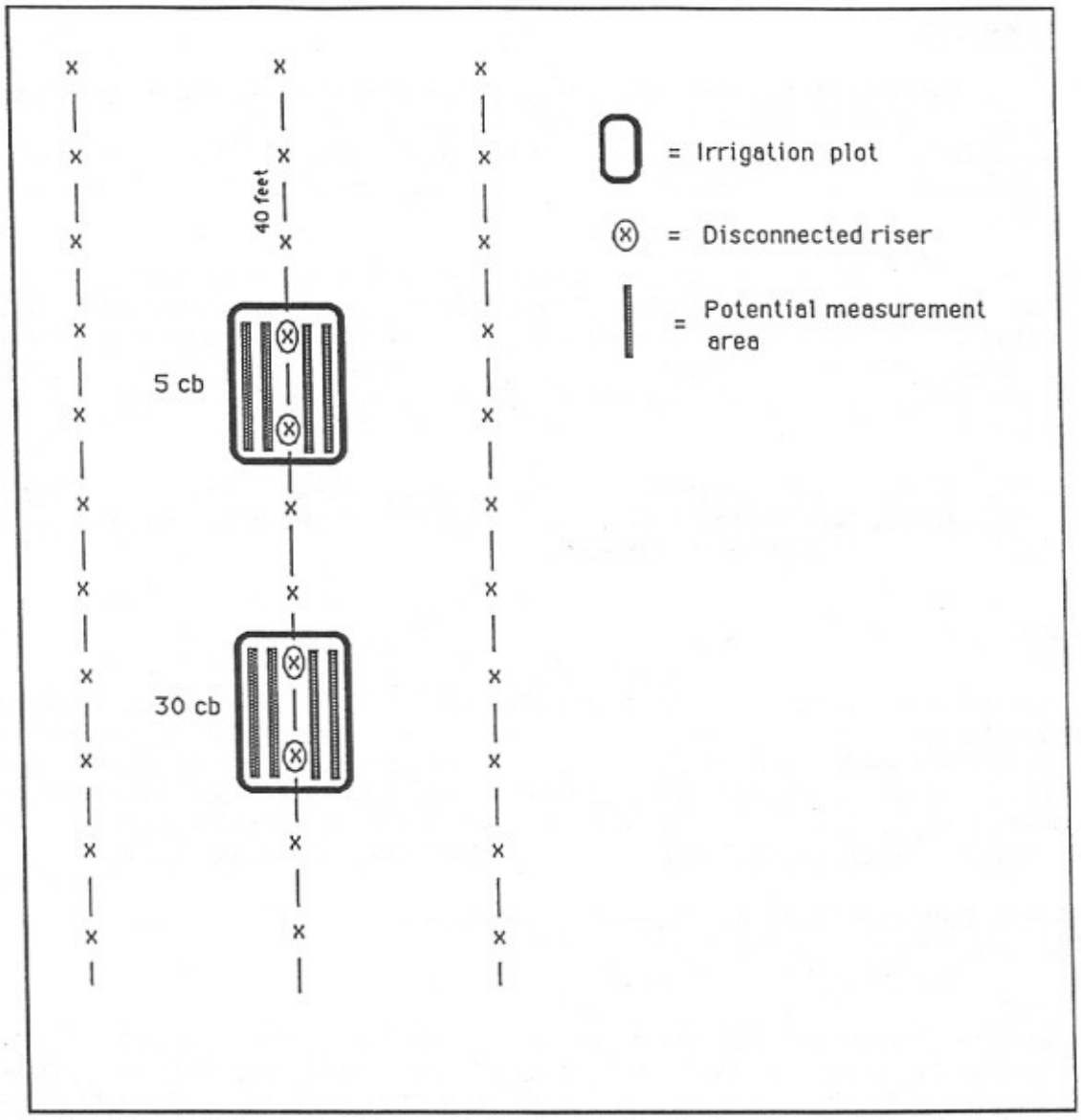


Figure 1. Partial typical seedbed replication in 1986 or 1987.

applications. In five of the studies, we sampled seedlings in the two beds on either side of the irrigation line, in the 20 foot portion of these four seedbeds midway between the two disconnected risers. In 1986 at New Kent, we pulled 4 risers, 2 adjacent risers on each side of a section, to create a much larger plot, and sampled seedlings in all 9 seedbeds between the two irrigation lines.

The number of seedbed replications by year and nursery was as follows:

Year	New Kent	Sussex
1985	4	5
1986	6	6
1987	2	3

The amount of irrigation water applied each time was monitored by the use of tin cans. A one-gallon tin can was placed in the center of each irrigation plot, and, after each irrigation, the water in the can was poured into a calibrated beaker that read directly in tenths of an inch. Rainfall amounts were taken from the nursery rain gauges. The average weekly irrigation water for a given treatment (Table 1) varied among the three years and between the two nurseries, due primarily to differences in rainfall. In 1986 and 1987, there was little difference between the 20 and 30 centibar treatments.

Our loblolly pine seedlings are top-clipped three times operationally, usually around August 1, August 25, and September 15. The primary purpose of top-clipping is to reduce seedling height. In these irrigation studies, we were interested in what effect the drier irrigation treatments would have on height growth. This presented a problem, therefore, because operational top-clipping would tend to reduce or obscure the effect of the irrigation treatments on height growth. In the 1985 studies, we never clipped the seedlings in the irrigation plots at Sussex. At New Kent, however, we clipped the irrigation plots during the second and third operational clippings to prevent the seedlings from getting too much taller than the main crop. In the 1986 and 1987 studies, the irrigation plots received all three operational clippings.

LIFTING SAMPLES FOR MEASUREMENT AND PLANTING

In December of each year, enough seedlings were lifted from each plot to sample for root collar diameter and top length as well as to plant in the field, except in 1985, when the samples at Sussex were not lifted until February. In 1985, we lifted 2 square foot samples, 6 inches wide across the bed; 3 samples per plot at New Kent and 2 per plot at Sussex. This resulted in a total of 48 samples at New Kent and 40 at Sussex. In 1986, we lifted 12-inch-long samples from individual drill rows, systematically distributed over the 9 seedbeds at New Kent (where we pulled 4 risers) and 4 seedbeds at Sussex. Eight samples were lifted from each plot, resulting in a total of 144 samples at each nursery. In 1987, we lifted 6-inch-long samples from individual drill rows, again systematically distributed: every other drill row in each of the 4 seedbeds. This resulted in 16 samples per plot and a total of 128 samples at New Kent and 192 at Sussex.

Table 1. Average seedbed density, weekly irrigation water, root collar diameter (32nds of an inch), percent of seedlings 7/64" diameter, top length, and percent of seedlings 4.5 inch top length; by year, nursery, and irrigation treatment.

	Year	Treatment	No./Ft.^{2}	Weekly Inches Irrigation	Dia.	Weekly Irrigation (Inches) % 7/64	Ht.	(% 4.5")
New Kent	1985	1" per week	45.0	.44	4.97	15	*	*
		8 cb	50.6	.39	4.66	19		
		15 cb	37.4	.19	5.12	15		
		30 cb	43.8	.11	5.04	18		
Sussex		1" per week	36.0	.69	5.26	13	8.2	4
		8 cb	38.5	.47	4.76	22	6.7	17
		15 cb	37.8	.23	4.39	26	6.0	20
		30 cb	35.1	.07	4.14	31	5.3	28
New Kent	1986	10 cb	32.4	.27	4.95	13	8.1	2
		20 cb	35.3	.12	4.58	18	7.3	6
		30 cb	31.6	.10	4.84	18	7.4	5
Sussex		10 cb	36.7	.44	4.83	15	7.6	6
		20 cb	38.6	.37	4.60	18	6.9	11
		30 cb	36.3	.28	4.63	19	6.8	12
New Kent	1987	5 cb	32.6	.47	5.16	12	8.1	2
		10 cb	32.2	.29	4.69	18	6.8	5
		20 cb	32.5	.20	4.59	22	6.0	14
		30 cb	35.6	.20	4.82	23	6.6	7
Sussex		5 cb	41.2	.62	4.41	17	8.4	1
		10 cb	33.0	.40	4.36	20	7.6	5
		20 cb	33.6	.23	4.37	23	6.5	15
		30 cb	35.5	.17	4.23	28	5.9	17

* Not measured

Individual samples were later counted into four separate lots and accumulated by treatment. One of these lots was used to randomly select seedlings for planting and the others were saved for measurement of diameter and top length.

FIELD PLANTING

The field planting in five studies consisted of randomized blocks, with a 20-seedling row of each irrigation treatment in each block. The 1985 Sussex study, however, was a completely random field design. In 1985, the New Kent study was replicated 4 times and the Sussex study 5 times. In 1986 and 1987, the two nurseries were combined in one study, with 4 replications in each year.

SEEDBED EFFECTS

The irrigation treatments affected height and diameter growth. Table 1 presents seedbed densities, average weekly irrigation water applied, root collar diameters, and top lengths. Generally, both height and diameter growth decreased as less irrigation water was applied, resulting in greater frequency of cull seedlings, either too small in diameter or too short (Figures 2 and 3).

The drier irrigation treatments sometimes tended to cause stunting, chlorosis, and increased mortality in the seedbeds. The occurrence of these conditions varied from year to year, from seedbed replication to seedbed replication, and from place to place within a particular irrigation plot.

In 1987, we had enough mortality from what we think were lesser cornstalk borers to be of real concern. This mortality was almost entirely limited to the 30 centibar plots. We believe that attack by the cornstalk borers was just as frequent in the moister treatments, but the seedlings were larger and so were usually not girdled. In the 30 centibar plots, when this attack occurred in mid to late summer, many of the seedlings were still so small that they were completely girdled.

The chlorosis that occurred in the drier irrigation plots was the lemon-yellow type of chlorosis that commonly shows up in July and is often attributed to iron deficiency. For some reason, this type of chlorosis was much more prevalent in the drier irrigation treatments, especially in 1987 at the Sussex nursery.

Nitrogen status confounded the effect of the irrigation treatments on diameter growth. We applied the same amount of nitrogen over all irrigation treatments, whenever nitrogen was operationally applied to the nursery. By October, the drier irrigation plots were a deeper green color, particularly in the 1985 study at both nurseries and the 1987 study at Sussex. There was a clear relationship between depth of color and irrigation treatments from the inch-per-week or 5 centibar treatments to the 30 centibar treatment. Obviously, the nitrogen status improved with decreasing water applied. There can be two reasons for this. First, there was probably less loss of nitrogen to leaching with the drier irrigation treatments. Second, seedling size

Figure 2. Seedling root collar diameter at lifting.

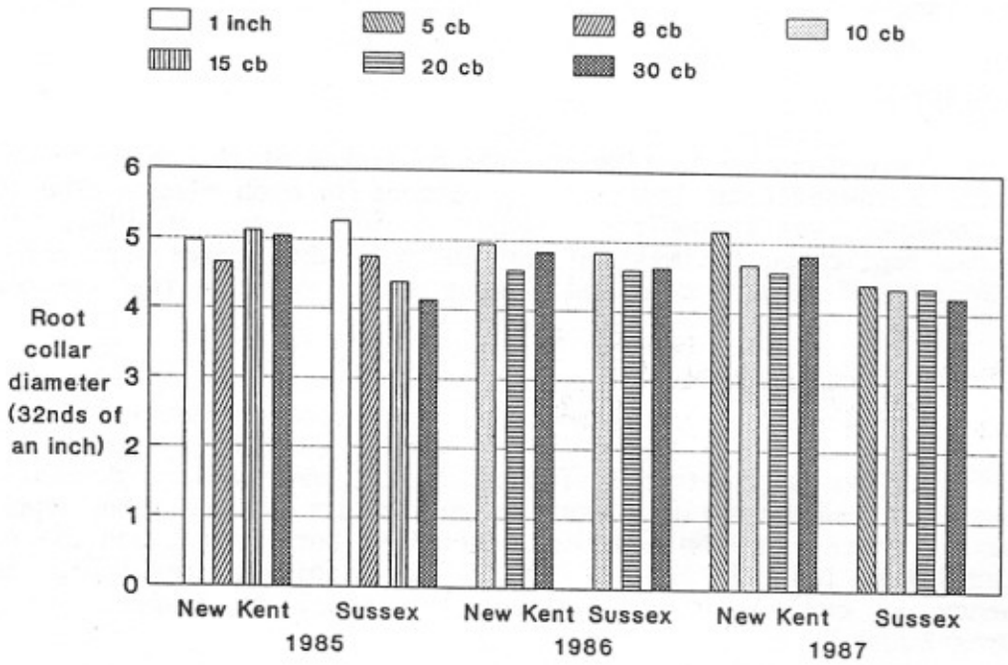
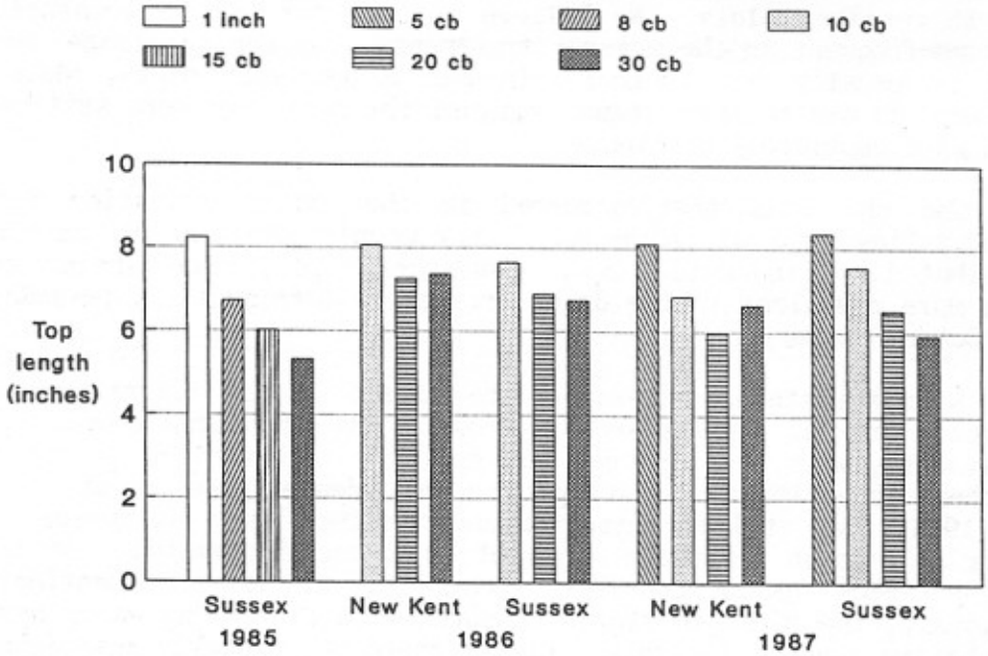


Figure 3. Seedling top length at lifting.



tended to be directly related to the amount of water applied. This means that there was more nitrogen available per unit of biomass with the drier irrigation treatments. From other studies we have done, we know that late season nitrogen fertilization can increase diameter growth. Consequently, the obviously better nitrogen status of the drier irrigation treatments in the fall of the year probably resulted in increased diameter growth. Consequently, seedling diameters for the drier irrigation treatments are probably larger than they would have been if we had reduced the amount of nitrogen applied so that nitrogen status was similar for all irrigation treatments. The net effect was that the drier irrigation treatments reduced height growth more than diameter growth, resulting in stockier seedlings with smaller height to diameter ratios.

FIELD RESULTS

Average survival percent and height, at age 3, for each nursery treatment and study year, are presented in Table 2 and Figures 4 through 9. Analyses of variance and Duncan's New Multiple Range Test were performed on the age 3 data, with survival percents transformed to arc sine percent. The results of the Duncan's test are incorporated into Table 2 and the complete analyses of variance are shown in Table 3. In general, the different irrigation treatments had little effect on survival, although there was a slight tendency for survival to increase with decreasing irrigation water, especially in 1985 and 1986 at Sussex. As with diameter growth in the seedbeds, we must be careful in interpreting results. We have learned from a number of other studies that shorter, stockier seedlings usually survive better than taller seedlings. Seedling height tended to be directly related to the amount of water applied. Consequently, the slight tendency for survival to improve with the drier irrigation treatments may be explained by the effect of the irrigation treatments on reducing seedling height, and have nothing to do with conditioning seedlings to survive under adverse soil moisture conditions after outplanting.

CONCLUSIONS

"One inch per week" was not a bad guide for irrigating our nurseries. We now irrigate at 5 centibars through the month of July to encourage rapid seedling growth. We have fewer problems with stunting, chlorosis, and mortality if we can push our seedlings just as rapidly as possible during the first half of the season. Around August 1, we change to irrigating at 10 centibars. If we feel seedlings are growing too rapidly, we will change to irrigating at 15 or 20 centibars. On several occasions we have been able to check height growth quickly by doing this. However, except for slowing the growth of seedlings growing too rapidly, we don't see any advantage in letting our seedbeds dry to 20 or 30 centibars before irrigating.

Table 2. Average survival percent and height in feet at age 3.[1/]

1985 New Kent Study-Lifted 12/10-18

Treatment	Survival Planted 1/16	Survival Planted 3/10	Survival Means	Height Planted 1/16	Height Planted 3/10	Height Means
1 inch per week	70.8 a	62.5 a	66.6	4.2 a	3.6 ab	3.9
8 cb	60.8 a	56.2 a	58.5	3.0 b	3.7 ab	3.4
15 cb	72.5 a	61.2 a	66.9	3.5 ab	3.8 a	3.7
30 cb	76.2 a	61.2 a	68.8	3.8 a	4.0 a	3.9
Means	70.1	60.3	65.2	3.6	3.8	3.8

1985 Sussex Study - Planted 2/21 Lifted 2/3-6

Treatment	Survival	Height
1 inch per week	79.0 a	5.6 a
8 cb	90.0 a	5.6 a
15 cb	84.0 a	5.0 a
30 cb	83.0 a	5.3 a
Means	84.0	5.4

1986 Study

Nursery	Lift Plant	Survival 12/3-8 12/17	Survival 12/3-8 3/6	Survival 2/26&27 3/6	Survival Means	Height 12/3-8 12/17	Height 12/3-8 3/6	Height 2/26&27 3/6	Height Means
N. Kent	10 cb	70.0 abc	70.0 abc	65.0 abc	68.3	3.2 a	3.2 a	3.0 a	3.1
	20 cb	75.0 ab	67.5 abc	66.2 abc	69.6	3.1 a	3.2 a	3.2 a	3.1
	30 cb	70.0 abc	71.2 abc	66.2 abc	69.2	3.3 a	3.4 a	3.4 a	3.3
Sussex	10 cb	56.2 c	67.5 abc	67.5 abc	63.8	3.1 a	3.1 a	3.3 a	3.2
	20 cb	65.0 abc	70.0 abc	66.2 abc	67.1	3.1 a	3.2 a	3.3 a	3.2
	30 cb	57.5 bc	76.2 a	77.5 a	70.4	3.2 a	3.2 a	3.1 a	3.2
Means		65.6	70.4	68.1	68.1	3.2	3.2	3.2	3.2

1987 Study

	Lift Plant	Survival 12/7&8 12/9	Survival 2/29&3/2 3/7	Survival Means	Height 12/7&8 12/9	Height 2/29&3/2 3/7	Height Means
N. Kent	5 cb	97.5 ab	93.8 abc	95.6	6.3 bcd	6.2 bcdef	6.3
	10 cb	98.8 a	96.2 abc	97.5	6.6 ab	5.8 efg	6.2
	20 cb	98.8 a	97.5 ab	98.1	6.4 abc	6.0 cdef	6.2
	30 cb	93.8 abc	95.0 abc	94.4	6.3 bcde	6.3 bcd	6.3
Sussex	5 cb	98.8 a	90.0 c	94.4	5.8 fg	5.4 g	5.6
	10 cb	98.8 a	95.0 abc	96.9	5.8 efg	5.8 fg	5.8
	20 cb	97.5 ab	98.8 a	98.1	6.2 bcdef	6.0 cdef	6.1
	30 cb	97.5 a	92.5 bc	95.0	6.8 a	5.9 def	6.3
Means		97.7	94.9	96.2	6.3	5.9	6.1

1/ Treatments not followed by the same letter are significantly different at the .05 level.

Figure 4. Field survival percent at age 3, 1985 study.

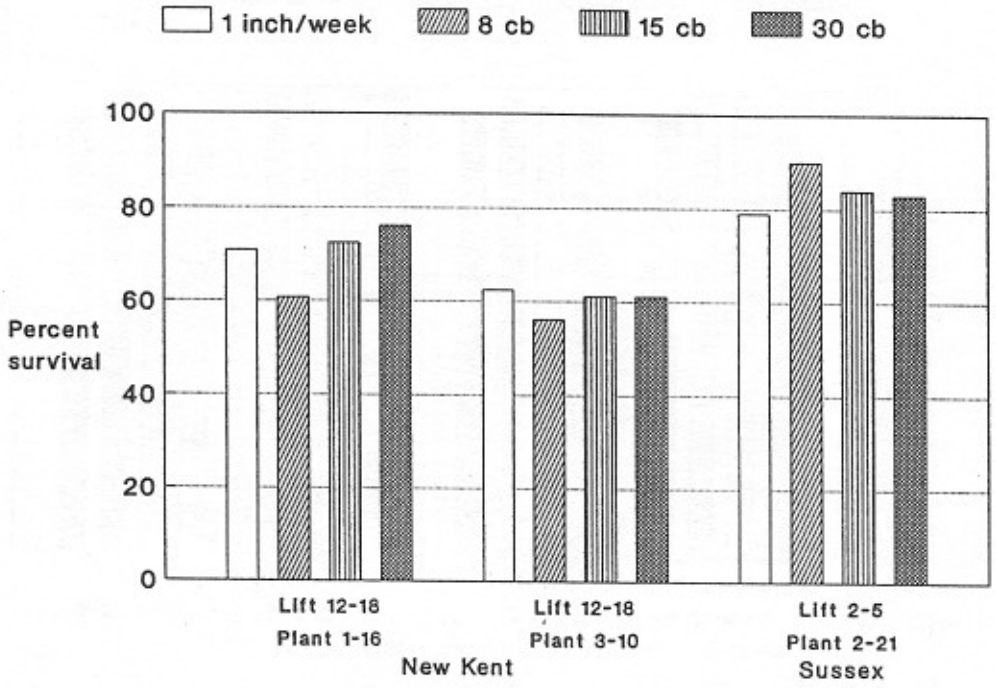


Figure 5. Field survival percent at age 3, 1986 study.

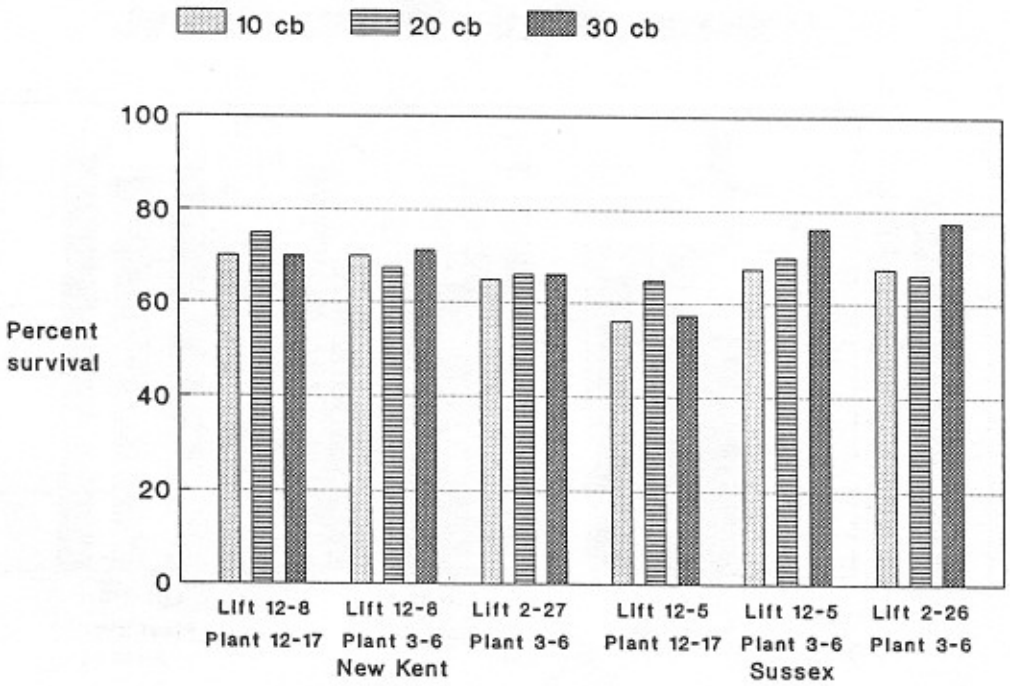


Figure 6. Field survival at age 3, 1987 study.

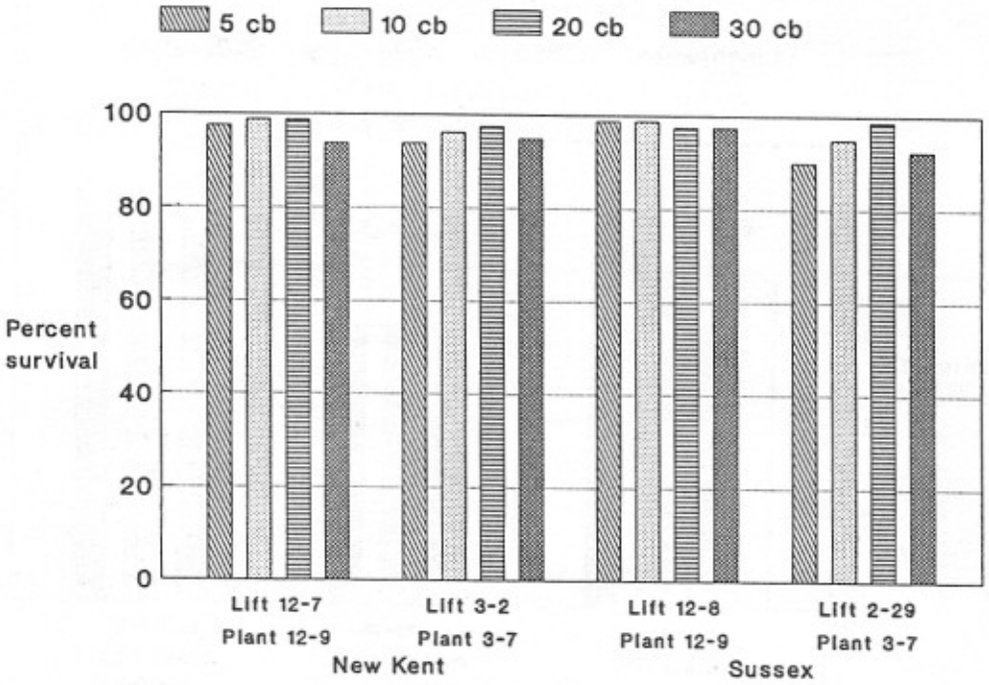


Figure 7. Average field height at age 3, 1985 study.

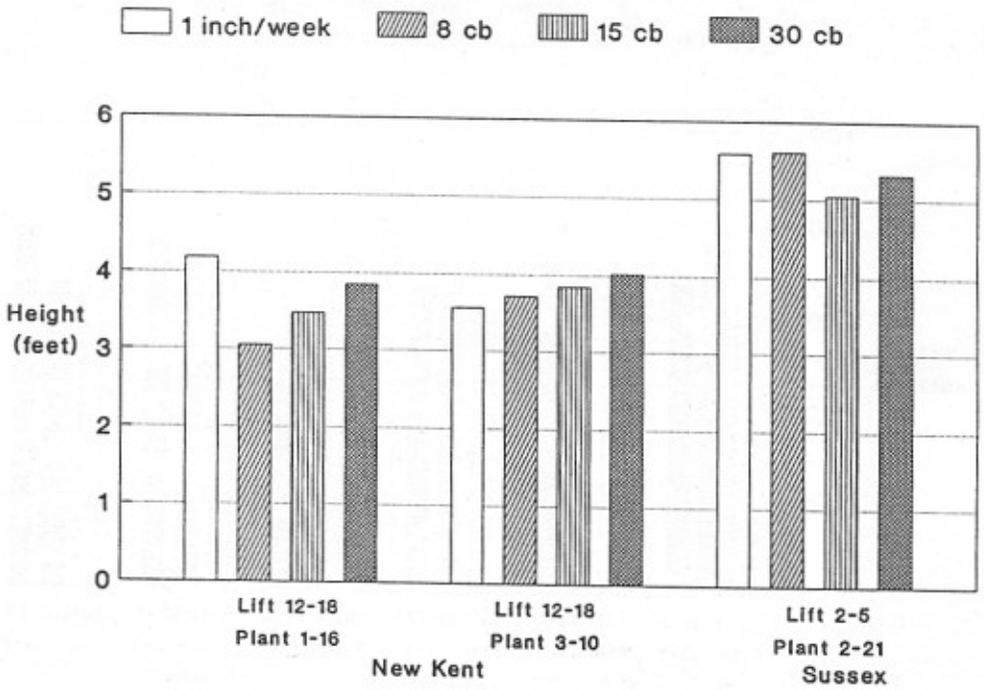


Figure 8. Average field height at age 3, 1986 study.

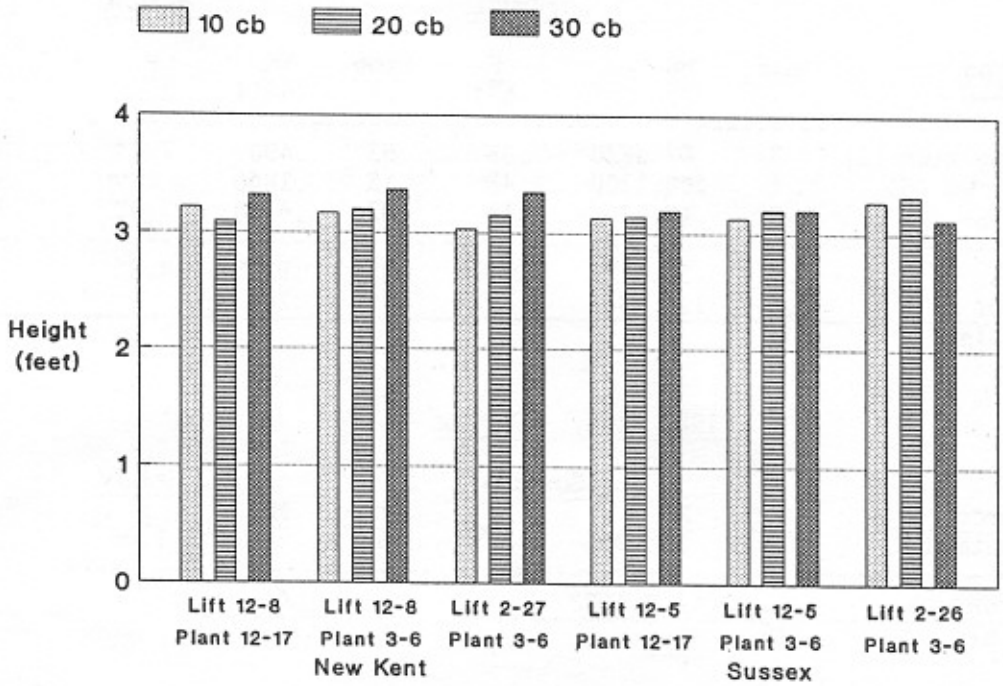


Figure 9. Average field height at age 3, 1987 study.

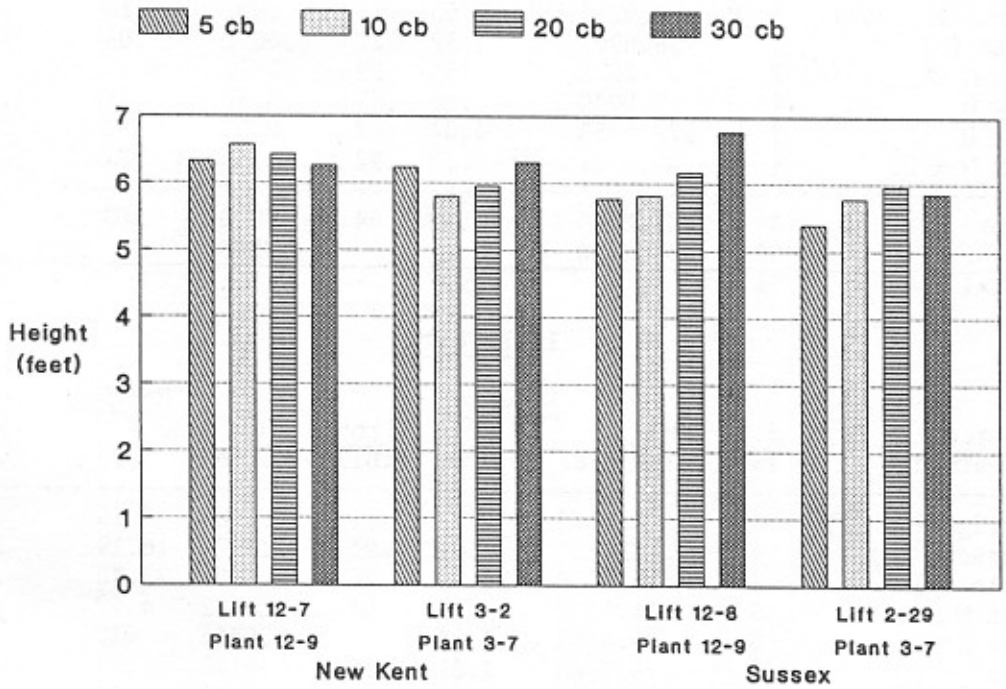


Table 3. Analyses of variance for age 3 measurements.

1985 Study - New Kent

		Survival			Height		
Source	d.f.	MS	F	Prob	MS	F	Prob
Treatments	7	78.1965	.674	.58	.5014	2.49	.05
Irrigation (I)	3	67.2820	.58	.63	.4900	2.43	.09
Storage (S)	1	288.1200	2.48	.13	.1800	.89	.35
I x S	3	19.1364	.16	.92	.6200	3.08	.05
Reps	3	33.9484	.29	.83	.9755	4.85	.01
Error	21	116.0847			.2013		
Totals	31						

1985 Study - Sussex

		Survival			Height		
Source	d.f.	MS	F	Prob	MS	F	Prob
Treatments	3	110.915	.76	.53	.3407	1.65	.22
Error	16	146.1902			.2071		
Totals	19						

1986 Study

		Survival			Height		
Source	d.f	MS	F	Prob	MS	F	Prob
Treatments	17	48.0961	1.08	.39	.0357	.38	.98
Irrigation (I)	2	34.2228	.77	.47	.0702	.74	.48
Nursery (N)	1	27.9254	.63	.43	.0091	.10	.76
Date (D)	2	58.5907	1.32	.27	.0072	.08	.93
I x N	2	23.2937	.53	.59	.1121	1.18	.31
I x D	4	39.9080	.90	.47	.0140	.15	.96
N x D	2	178.6255	4.04	.02	.0303	.32	.73
I x N x D	4	10.1527	.23	.92	.0257	.27	.90
Reps	3	127.8936	2.89	.04	.0080	.08	.97
Error	51	44.2418			.0948		
Total	71						

1987 Study

		Survival			Height		
Source	d.f	MS	F	Prob	MS	F	Prob
Treatment	15	102.7887	2.38	.013	.5100	5.99	.000001
Irrigation (I)	3	160.6443	3.72	.018	.4385	5.15	.004
Nursery (N)	1	.5814	.013	.91	1.3776	16.19	.0002
Date (D)	1	456.7838	10.59	.002	1.9987	23.48	.000015
I x N	3	11.9302	.28	.84	.4072	4.78	.006
I x D	3	88.0282	2.04	.12	.0314	.37	.78
N x D	1	79.7002	1.85	.18	.0186	.22	.64
I x N x D	3	74.3189	1.72	.18	.5413	6.36	.001
Reps	3	80.5667	1.87	.15	.4618	5.43	.003
Error	45	43.136			.0851		
Totals	63						