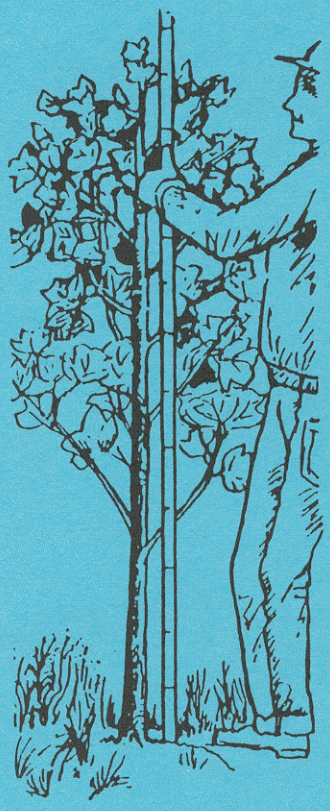

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Sowing Five Clonal Lots of Loblolly Seed Separately or Randomly Mixed -- Results After 20 Years

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SOWING FIVE CLONAL LOTS OF LOBLOLLY SEED SEPARATELY OR RANDOMLY MIXED -- RESULTS AFTER 20 YEARS

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Sowing Procedure

In the spring of 1973, open pollinated seed from 5 loblolly clones in our first generation seed orchard were sown either separately (pure) or randomly mixed (random) in an 18 foot length of a single seedbed at our New Kent Nursery. The seedbed was carefully chosen for having consistently produced very uniform seedlings over the years. The 5 clones were selected to provide a range in speed of germination, from very slow to fast, based on earlier observations of germination rates in small plots of control-pollinated seed sown to produce progeny test seedlings. The 5 clones used, in order form fastest to slowest germinating, were 508,512, 14-15, 506, and 6-10.

The 5 clonal seed lots, both pure and randomly mixed, were replicated 4 times within the 18 foot length of seedbed. The spacing was 6 inches between rows and $^{2}/_{3}$ inch between seed spots within rows, and 2 seeds were sown at each spot. This spacing provided a density of 36 seed spots per square foot. The 18 foot length of seed bed was in the middle of 1 of 3 seedbeds in which progeny test seedlings were being grown.

In the randomly sown plots, the randomization was done in groups of 5. The first 5 spots in a drill row each was randomly assigned a different one of the 5 clones, then the next 5 spots each received a different clone and so on. Each of the 4 seedbed replications was randomized individually. Colored toothpicks, a different color for each clone, were placed at each seed spot to identify the parent of each seedling. The seed was sown on April 30, and when it started to germinate, seedlings were counted every day, except on weekends. Thinning to 1 seedling per spot started on June 15 and was complete on July 5.

Lifting Procedure

The seedlings were lifted on February 25 and 26, 1974. After undercutting, seedlings were carefully lifted one at a time. As each seedling was lifted, the root collar diameter and top length were measured to the nearest $^{1}/_{32}$ inch and inch respectively. Seedlings from the randomly-sown plots were placed in specially constructed racks in the same order as they grew in the seedbed. This was so seedlings could be planted in the field in the same random pattern as they grew in the seedbed, with the same neighbors that they had in the seedbed. Where seed spots were blank (neither of the 2 seeds germinated, or one or both germinated but later died), "commercial check" seedlings from adjacent progeny test plots were substituted. These commercial check seedlings were also measured for root collar diameter and top length before being placed in the racks.

Seedlings from the pure-sown plots were lifted and measured in the same manner, and kept separate by clone. In the field, the 5 clones were randomly interplanted using the same randomization patterns that the randomly-sown plots were both seeded and planted by.

Average seedbed density at time of lifting was 29.8 and 28.4 seedlings per square foot for pure- and random-sown plots respectively.

Field Planting

The seedlings were planted on February 28 on a typical upland site on the Appomattox-Buckingham State Forest in the central piedmont of Virginia. It was a cut-over area that had been site-prepared by prescribed burning. Four pairs of plots, each pair on a uniform site, were laid out with a pure-sown and random-sown plot randomly assigned to each pair. Each plot had 12 rows of 17 seedlings each, with a central measurement plot of 10 rows of 15 seedlings each (a 15 seedling row included 3 randomized groups of 5 clones each). Two additional buffer rows were planted around each pair of plots. Spacing was 7.5 by 7.5 feet.

A painted wire was placed by each seedling, the same colors as the toothpicks used in the seedbed. Commercial check seedlings were marked with unpainted wires.

Replacement planting was done on May 9 and again on May 17, using commercial check seedlings. A total of 36 seedlings were planted out of a total of 1,632 seedlings planted initially. Replacement seedlings were planted next to seedlings that looked like they might die. Of the 36 replants, 9 were later pulled up because the original seedling survived.

After one season, in January of 1975, there were 29 dead seedlings on the 8 plots. On March 3, 1975, these were replaced with 1-1 commercial check seedlings that had been transplanted into a "holding" bed during the spring of 1974.

Heights were measured after 1, 2, 3, 4, 5, 6, 7, 11, and 19 seasons in the field, to the nearest .1 foot for the first 3 years and the nearest foot thereafter. Diameter at breast height was measured to the nearest .1 inch after 9 and 19 seasons.

Seedbed Results

Seedbed results were published in 1978[1], and are summarized in Table 1.

[1]Wesser, Ronald G. 1978. Proceedings of Southeastern Nurseryman's Conference, p. 15-19.

Table 1. Germination percent after 25 and 45 days, and average root collar diameter (32nds inch) and percent cull seedlings (<3.5/32 inch) when lifted, by clone and sowing method.

	Percent Germination		Root Collar Diameter		Percent Cull	
Clone	25 Days	45 Days	Pure	Random	Pure	Random
508	67	78	4.81	5.37	11	4
512	54	94	4.70	5.88	19	7
14-15	40	68	4.79	4.26	11	19
506	26	88	4.72	4.17	12	22
6-10	10	39	5.18	4.14	14	37

In the pure-sown plots, average root collar diameter was similar among clones except for clone 6-10. The larger diameter of 6-10 was probably caused by a considerably lower seedbed density resulting from low final germination. In the random-sown plots, on the other hand, there was much more variation among clones. The two fastest germinating clones (508 and 512) were much larger than the two slowest germinating (506 and 6-10). The seeds that germinated quickly tended to produce dominant seedlings and the slow-germinating seeds produced a higher proportion of intermediate and suppressed seedlings. This is reflected in the percent of undersized seedlings when lifted (Table 1).

Field Results

Survival after 19 seasons in the field averaged 96.7 for pure-sown and 96.0 for random-sown plots. Among clones, average survival ranged from 95.0 to 98.3 on pure-sown plots and 93.2 to 97.9 on random-sown (Table 2). Stand density was high. Basal area per acre averaged 186 square feet on pure-sown and 184 on random-sown plots (measurement plots, 10 rows of 15 seedlings each, contained 0.194 acres).

Table 2. Average survival after 19 seasons in the field, by sowing method and clone.

	Pure-Sown		Random-Sown	
Clone	No. Planted	Survival	No. Planted	Survival
508	120	98.3	108	96.3
512	120	97.5	108	97.2
14-15	120	95.0	84	97.6
506	120	95.0	97	97.9
6-10	120	97.5	44	93.2
Commercial Check	--	--	139[2]	93.5
Totals and Means	**600**	**96.7**	**580**	**96.0**

[2] Only the commercial check seedlings planted on February 28, not later replacement plantings in May of 1974 and March of 1975.

Figure 1 presents average top length when lifted and average height in the field at each measurement, by sowing method for each clone. At the final measurement after 19 seasons in the field (age 20 from seed) trees more than 2 standard deviations shorter than the mean, for each clone in each replication, were excluded. The number of trees excluded was about the same for each clone, ranging from 1.9 percent for 6-10 to 4.8 percent for 506. Many of the excluded trees had been damaged by ice storms.

When lifted, seedlings grown in pure plots were slightly taller than seedlings grown in random plots (Figure 1). By age 2 (after 1 season in the field) an interaction between sowing method and clones had developed. Clones 508 and 512, the faster germinating, benefited from random sowing where they tended to dominate their slower germinating neighbors and produced larger diameter seedlings (Table 1). Clone 6-10, the slowest germinating clone, was at a disadvantage in random-sown plots and produced considerably larger seedlings in pure plots where it did not tend to be suppressed by faster germinating clones (Table 1).

These differences related to sowing method increased each year through age 5 from seed. Between age 5 and 6, the differences still increased slightly for 508 and 512 but decreased for 6-10 (Table 3 and Figure 1). A split plot analysis of variance was performed on average heights at age 6 (from seed). The main effect of sowing method was not statistically significant (probability of a larger F = .61), but the differences among clones and the interaction of sowing method and clones were (probability of a larger F = 0.0062 and 0.026). After age 6, the differences among clones continued to increase, but the interaction between clones and sowing method weakened and was gone by age 20.

Table 3. Average height[3] by sowing method and clone, for age from seed.

		Clone				
Age from Seed	**Sowing Method**	**508**	**512**	**14-15**	**506**	**6-10**
1	Pure	0.65	0.64	0.58	0.62	0.55
	Random	0.56	0.62	0.52	0.47	0.48
2	Pure	1.17	1.35	1.42	1.20	1.56
	Random	1.32	1.59	1.34	1.20	1.26
3	Pure	3.40	3.75	3.66	3.46	3.95
	Random	3.60	4.07	3.51	3.47	3.49
4	Pure	5.93	6.17	6.09	6.08	6.63
	Random	6.28	6.68	6.00	6.14	5.94
5	Pure	9.22	9.47	9.33	9.52	9.96
	Random	9.70	10.02	9.30	9.69	9.18
6	Pure	12.80	13.28	12.87	13.32	13.66
	Random	13.36	14.02	13.03	13.64	13.14
7	Pure	16.64	16.99	16.36	16.98	17.30
	Random	17.27	17.77	16.74	17.62	16.98
8	Pure	19.67	19.93	19.42	20.12	20.62
	Random	20.21	20.70	19.70	20.84	20.00
12	Pure	32.24	33.04	31.66	33.20	33.04
	Random	32.63	33.45	31.78	33.60	32.13
20	Pure	51.74	53.23	50.38	53.81	52.60
	Random	52.76	54.78	51.13	54.50	53.52

[3] For age 1, heights are top lengths measured as seedlings were lifted.

At age 20, randomly sown seedlings were taller than pure-sown for all 5 clones. In an analysis of variance, the effect of sowing method was significant (probability of a larger F = 0.044). In the 20 comparisons of random and pure-sown seedlings (4 replications of 5 clones), random-sown seedlings were taller in 17. We can think of no logical reason for this. By coincidence, the random-sown plot of each pair (block), must have been on a slightly better site, even though we tried to lay out blocks that would be uniform for site quality.

At age 20, the differences among clones were highly significant (probability of a larger F = 0.0000001). Clones 512 and 506 were significantly taller than the other 3 clones.

Average height at age 7 (from seed) on random-sown plots was related to initial root collar diameter (Figure 2), but very little of the variation in height at age 7 was explained by initial root collar diameter (Table 4). Separate regressions were calculated for each clone. The amount of variation accounted for by initial diameter ranged from 0.9 percent for clone 6-10 to 9.5 percent for clone 508. The slopes ranged from 0.14 (increase in feet at age 7 per $^1/_{32}$ inch increase in initial diameter) for clone 6-10 to 0.58 for clone 506. Figure 3 presents a plotting of height at age 7 over initial root collar diameter for clone 506, the clone with the steepest slope, to illustrate how little of the variation in height (8.7 percent) was explained by initial root collar diameter. Even though initial diameter explained very little of the variation in height at age 7, the regressions were statistically significant for all but clones 512 and 610 (Table 4). Slopes for individual clones were not significantly different (F for common slopes = 1.20 with 5 and 566 degrees of freedom), and the common slope is 0.33.

By age 20 (from seed), the slopes for individual clones were more erratic (Figure 4 and Table 4). Only the regressions for clones 508 and 506 were still statistically significant (Table 4). Slopes for individual clones were again not significantly different (F for common slopes = 1.71 with 5 and 545 degrees of freedom), and the common slope is 0.42.

Table 4. Results of linear regressions of height at age 7 and 20 over initial root collar diameter when lifted: slopes, amount of height variation explained (r^2), and probability of a larger F.

	Age 7			Age 20		
Clone	**Slope**	**r^2**	**Probability**	**Slope**	**r^2**	**Probability**
508	0.51	0.095	0.001	1.15	0.087	0.002
512	0.17	0.028	0.084	0.22	0.009	0.338
14-15	0.56	0.068	0.017	-0.49	0.006	0.472
506	0.58	0.087	0.003	1.11	0.043	0.045
6-10	0.14	0.009	0.551	0.42	0.012	0.494
Commercial Check	0.30	0.035	0.028	0.23	0.005	0.420

Progeny test seedlings were grown in pure-sown seedbed plots when the original (first generation) parents were tested. In this study on the pure-sown plots, clone 6-10 would have been picked as the fastest grower through age 8, but 512 and 506 caught up to 6-10 by age 12 and had surpassed it by age 20.

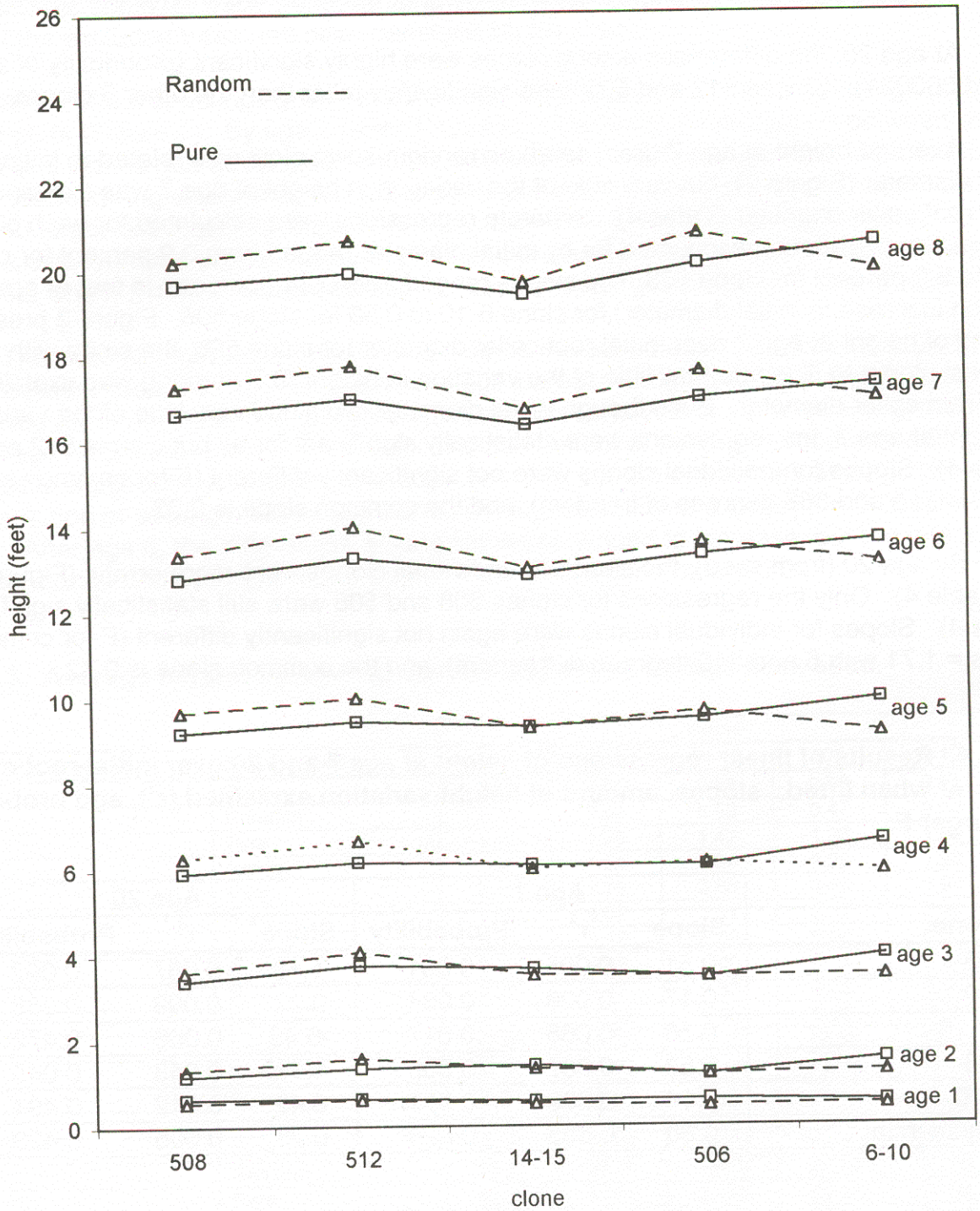
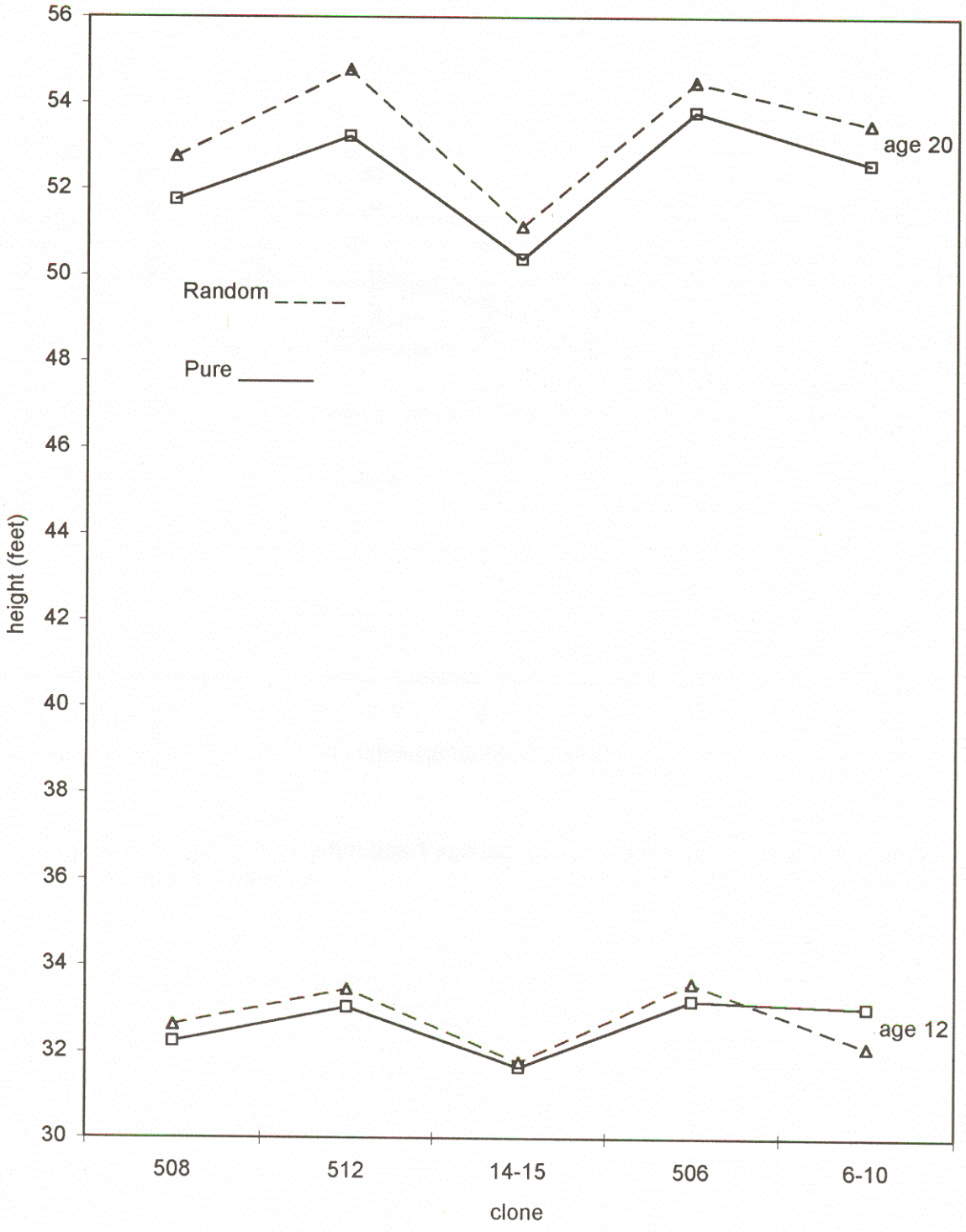


Figure 1. Average height by sowing method, clone, and age from seed.



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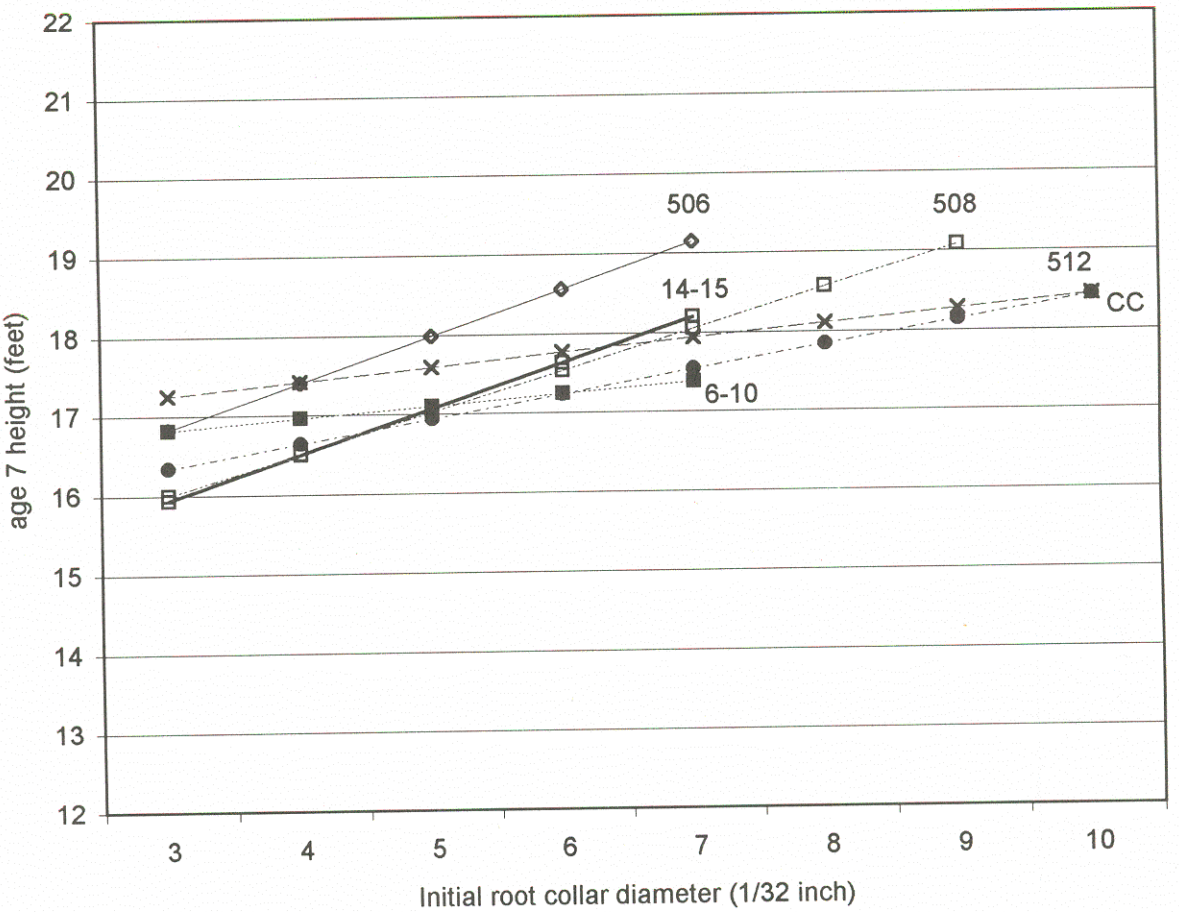


Figure 2. Relationship between height at age 7 and initial root collar diameter.

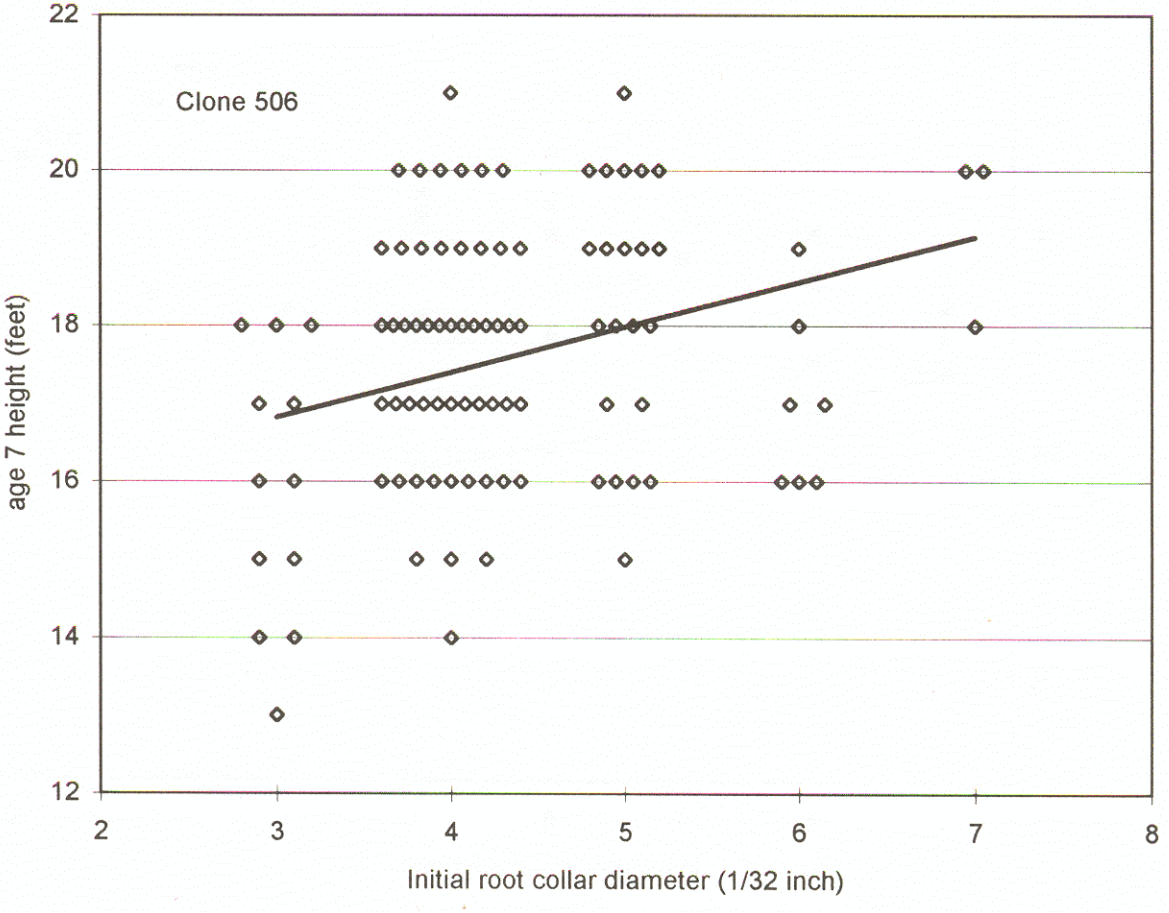
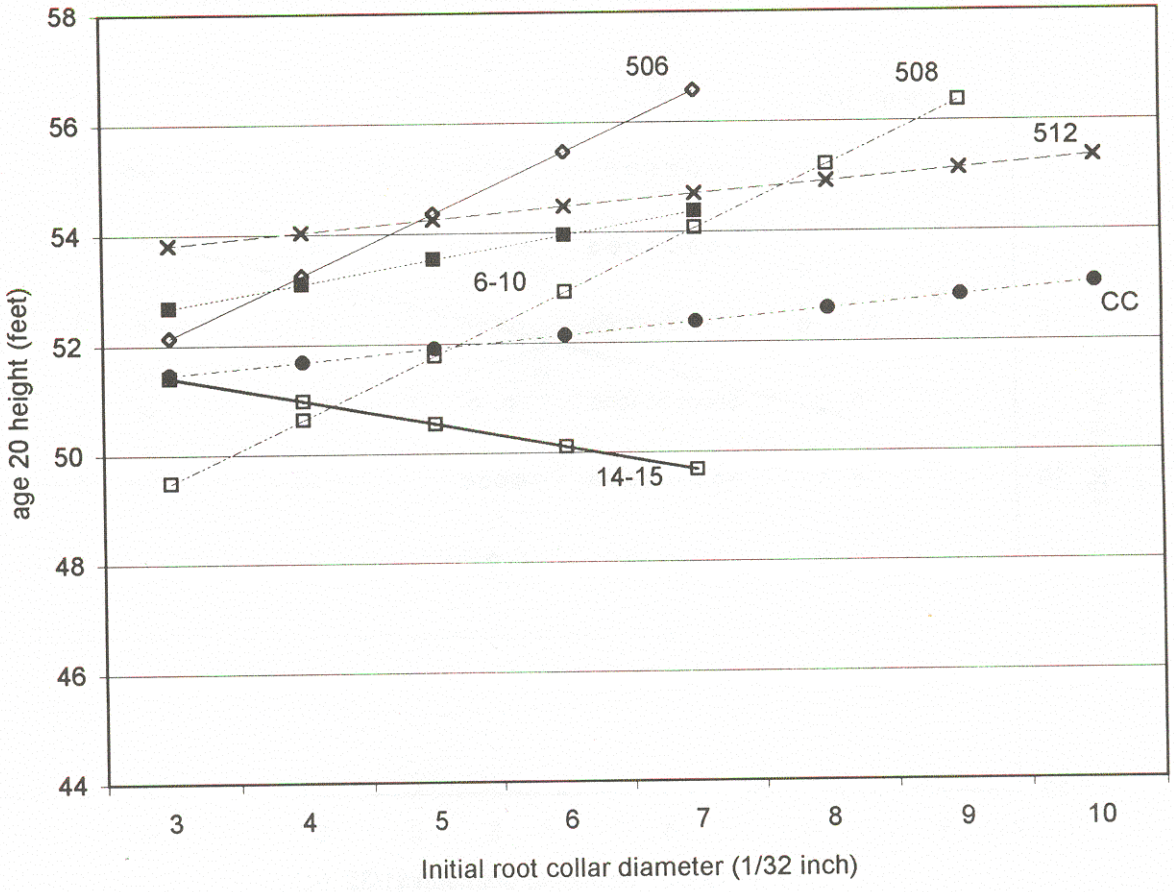


Figure 3. Plotting of height at age 7 over initial root collar diameter for the 97 seedlings of clone 506.



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