Response to CROP-TREE RELEASE by 7-year-old stems of Yellow-Poplar and Black Cherry

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U.S.D.A. FOREST SERVICE RESEARCH PAPER NE-253
1973

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FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
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MANUSCRIPT SUBMITTED FOR PUBLICATION 1 JUNE 1972

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ABSTRACT

Five years after crop-tree release of yellow-poplar and black cherry stems in a 7-year-old stand of Appalachian hardwoods, measurements indicated that released trees were but slightly superior to control trees in height, diameter, and crown position. Sprout regrowth of cut tree stems and grapevines had largely nullified the effects of release. Indications are that for release to be effective, crop trees of these species on good sites should be 15 to 20 feet tall.

THIS is a report on the results of a crop-tree release made in a 7-year-old even-aged hardwood stand growing on an excellent site in the Central Appalachians. The objective of this study was to test the feasibility of making a crop-tree release as soon as crop trees could be selected—immediately after the canopy closed and crown classes could be distinguished.

The purpose of making the operation so early was to enhance the possibility of improving species composition. A crop-tree release was used rather than an area-wide thinning because releasing individual trees is much less expensive; and when interest rates are considered, the carrying charge for work done early in the life of a stand mounts high. To be economically justified, such work must result in an appreciable dollar improvement in the stand at harvest time.

To measure the biological response to the release operation, a number of variables were examined in detail.

The relationships established by this study add to the growing body of information about early intermediate operations in even-aged hardwood stands. More data of this nature are needed before detailed guidelines can be developed for operations of this kind—or even before a good case can be made that precommercial operations are worthwhile.

DESCRIPTION OF THE AREA

The study locale was the Fernow Experimental Forest near Parsons, West Virginia. Site quality was excellent: site index 75 to 80 for oak. The soil was a well-drained silt loam derived mostly from sandstone and shale, but with some limestone influence. Elevation of the study area was about 2,800 feet, and steepness of slope averaged about 30 percent. Annual rainfall was about 59 inches and was well-distributed; the frost-free growing season was about 4½ months.

The 7-year-old stand developed as a result of clear-cutting a well-stocked 95-year-old unmanaged hardwood stand containing a wide variety of desirable species. The harvest produced 23,500 board feet of sawlogs and 15 cords of pulpwood per acre. All 1- to 5-inch stems left standing following this harvesting were felled shortly thereafter.

STUDY METHODS

The sample-tree population included the two shade-intolerant species, black cherry (*Prunus serotina* Ehrh.) and yellow-poplar (*Liriodendron tulipifera* L.). For each species, three crown classes were studied: dominants, codominants, and intermediates. For each species/crown-class combination, 40 stems were designated; of these, half were chosen at random as treatment trees and half were untreated controls. Thus a total of 240 sample trees were used: 2 species x 3 crown classes x 2 treatment classes (release and control) x 20 trees per group.

These sample trees were permanently numbered and identified in the 7-year old hardwood stand. The following measurements were taken on each of them: d.b.h., height, and length of clear stem. Repeat measurements were made after two and five growing seasons. At each repeat measurement, crown classes were re-identified.

After the initial classification and measurements were made, the crop trees designated for treatment were released by cutting around the base of each in a 5-foot radius all woody stems that were over half as tall as the crop trees. All grapevines growing in the crop trees were severed. This operation left all released trees in a dominant crown position.

RESULTS

Effect on Height

When the data were analysed for the 5-year after-treatment period, they indicated that the height of released trees did not differ significantly from the height (at the 5-percent level) of the control stems (table 1). This was true for all three crown classes: dominant, codominant and intermediate.

However, when the data were analysed for the 2-year period and the following 3-year period separately (the 5-year period was split), a different picture emerged (figs. 1 and 2). For the 2-year period after release (7 to 9 years), released stems of all crown classes of both species grew slower than the control stems. Because we took only 2-year measurements, we do not know whether growth was reduced both years or only the first. For the following 3-year period, the situation was reversed; and released stems of all crown classes of both species grew slightly faster than control stems. Not until more time has passed will we be able to determine the duration of this trend.

This reversal of height growth advantage is consistent with the findings of Allen and Marquis (*1970*). They found that height growth was reduced by very heavy thinning and favored by moderate thinning—conditions approximated for the released crop trees during the 2-year and 3-year measurement periods after the release operation.

Two other height/growth relationships show up in the data. First is the expected greater height and greater height growth of the more dominant trees, both released and control. In addition, the data indicated that until about 10 years of age black cherry grew faster in height than yellow-poplar, but then yellow-poplar grew faster (fig. 3 and table 1).

Table 1.—Total heights and height-growth rates for released and unreleased stems

Crown class before treatment	Treatment	Sample trees[a]	Total height[b] At 7 years	At 9 years	At 12 years	Height growth 7 to 9 years annual	9 to 12 years annual
		No.	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
			YELLOW-POPLAR				
Dominant	Release	20	10.55	14.76	24.51	2.10	3.25
Dominant	Control	20	10.22	15.28	24.01	2.53	2.91
Codominant	Release	19	8.84	12.06	20.66	1.61	2.87
Codominant	Control	17	9.03	13.62	20.48	2.30	2.29
Intermediate	Release	16	7.69	10.25	14.92	1.28	1.56
Intermediate	Control	14	8.25	11.57	14.92	1.66	1.12
			BLACK CHERRY				
Dominant	Release	20	13.10	17.61	25.26	2.26	2.55
Dominant	Control	20	12.98	18.14	25.58	2.58	2.48
Codominant	Release	19	9.84	13.46	20.15	1.81	2.23
Codominant	Control	20	9.82	14.29	19.18	2.24	1.63
Intermediate	Release	19	7.66	10.22	15.21	1.28	1.66
Intermediate	Control	17	7.79	11.52	14.81	1.86	1.10

[a]Data are based on the trees still living at 12 years; 20 sample trees were originally designated in each class.
[b]Release and original measurements at 7 years, with succeeding measurements at 9 and 12 years.

Figure 1.—Yellow-poplar heights.

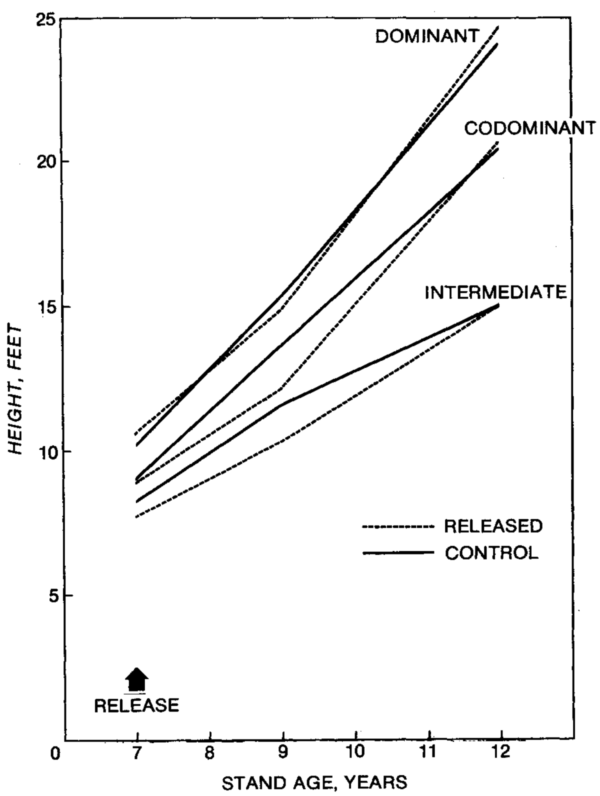

Figure 2.—Black cherry heights.

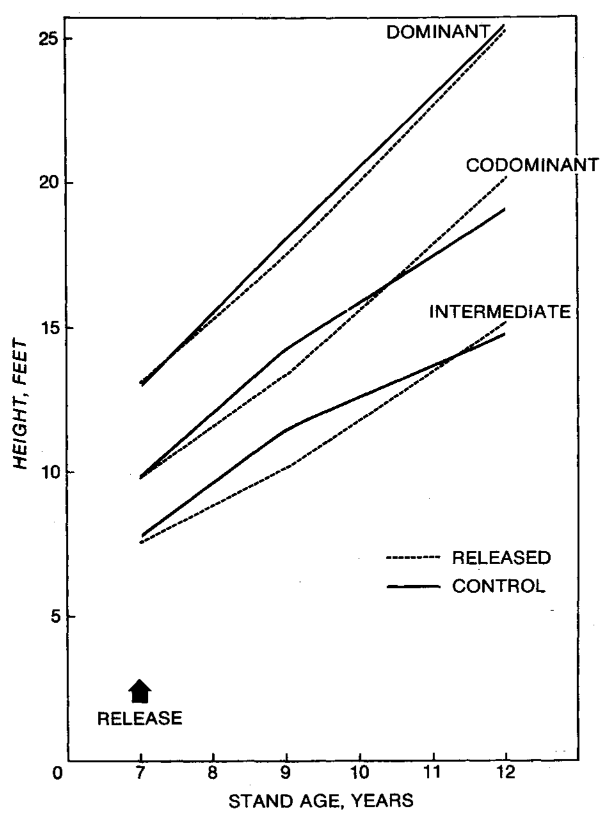

Figure 3.—Height growth of dominant unreleased stems of yellow-poplar and black cherry.

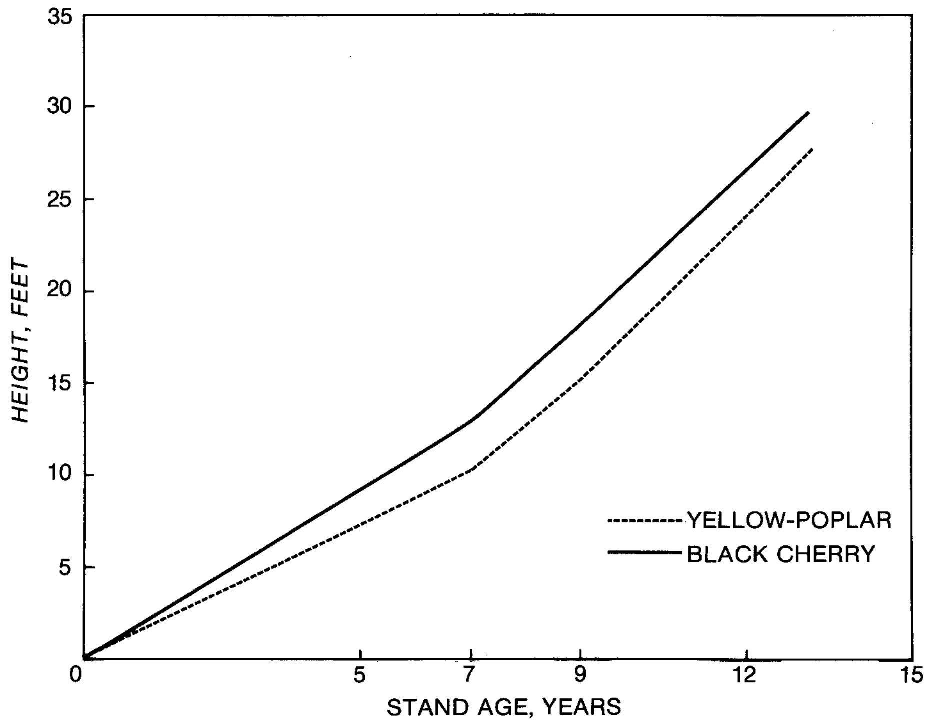

Table 2.—D.b.h. and d.b.h. growth rates for released and unreleased trees

Crown class before treatment	Treatment	Sample trees[a]	D.b.h.[b] At 7 years	D.b.h.[b] At 9 years	D.b.h.[b] At 12 years	D.b.h. growth 7 to 9 years annual	D.b.h. growth 9 to 12 years annual
		No.	*In.*	*In.*	*In.*	*In.*	*In.*
		YELLOW-POPLAR					
Dominant	Release	20	0.91	1.53	2.72	0.31	0.40
Dominant	Control	20	.86	1.46	2.54	.30	.36
Codominant	Release	19	.62	1.01	1.69	.20	.23
Codominant	Control	17	.64	1.12	1.78	.24	.22
Intermediate	Release	16	.47	.72	1.04	.12	.11
Intermediate	Control	14	.49	.76	1.01	.14	.08
		BLACK CHERRY					
Dominant	Release	20	1.12	1.79	2.80	0.34	0.34
Dominant	Control	20	1.11	1.80	2.71	.34	.30
Codominant	Release	19	.64	1.05	1.56	.20	.17
Codominant	Control	20	.69	1.06	1.42	.18	.12
Intermediate	Release	19	.39	.67	.99	.14	.11
Intermediate	Control	17	.40	.62	.77	.11	.05

[a]Data are based on the trees still living at 12 years; 20 sample trees were originally designated in each class.
[b]Release and original measurements at 7 years, with succeeding measurements at 9 and 12 years.

One reason, which at least in part accounts for the early growth superiority of black cherry, is that many of the black cherry stems were small seedling-sprouts, but all the yellow-poplars were seedlings.

Effect on Diameter

No statistically significant difference showed up between diameter of released and control stems after 2 years and 5 years (table 2). However, for the last 3 years of the 5-year period, diameter growth was slightly greater for the released stems, particularly for the intermediate crown class where for black cherry the difference was significant at the 5-percent level. This suggests the possibilities of the same sort of delayed reaction that occurred with height growth, but to a lesser degree.

As with height growth, diameter growth was much greater for the more dominant stems, both released and unreleased. Also, as with height growth, during the measurement period yellow-poplar caught up with and surpassed black cherry in diameter growth.

Effect on Length of Clear Stem

Release retarded stem pruning, at least temporarily. This is evidenced by the greater gain in clear length during the 2-year after-release period by the unreleased trees compared to the released trees (table 3). This relationship held for all crown classes of both species. During the succeeding 3 years, however, the released stems of all crown classes of yellow-poplar cleared up at a faster rate than control stems, indicating that for this species the two classes of trees are now approaching equality in length of clear stem. This same trend was not evident with black cherry.

No statistical difference in length of clear stem was evident between crown classes for either species, but as a *percent* of *total height*, length of clear stem increased with decreasing crown class; intermediate trees had a greater percent of stem in clear length than had dominants.

At 12 years of age, yellow-poplar had a greater percent of tree height in clear length

Table 3.—Length of clear stem and clear-stem increase for released and unreleased trees

Crown class before treatment	Treatment	Sample trees[a]	Length of clear stem[b] At 7 years	At 9 years	At 12 years	Clear-stem increase 7 to 9 years annual	9 to 12 years annual
		No.	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
			YELLOW-POPLAR				
Dominant	Release	20	3.63	4.26	10.56	0.32	2.10
Dominant	Control	20	2.97	5.04	10.70	1.04	1.89
Codominant	Release	19	3.66	4.67	9.99	.51	1.77
Codominant	Control	17	3.11	6.09	10.59	1.49	1.50
Intermediate	Release	16	3.76	4.84	8.17	.54	1.11
Intermediate	Control	14	4.13	6.40	9.14	1.14	.91
			BLACK CHERRY				
Dominant	Release	20	3.50	3.97	7.50	0.24	1.18
Dominant	Control	20	3.49	4.86	9.34	.68	1.49
Codominant	Release	19	3.35	4.11	7.55	.38	1.15
Codominant	Control	20	3.86	4.89	9.88	.52	1.66
Intermediate	Release	19	3.02	3.49	6.64	.24	1.05
Intermediate	Control	17	3.66	4.85	6.88	.60	.68

[a]Data are based on the trees still living at 12 years; 20 sample trees were originally designated in each class.
[b]Release and original measurements at 7 years, with succeeding measurements at 9 and 12 years.

than had black cherry, for both release and control trees. Yellow-poplar is obviously a faster pruner.

Effect on Dominance Classification

As stated previously, crown classes were determined before release, but all released trees were left after the operation in a dominant position. The control (unreleased) trees were left in their original crown position. At 5 years, all sample trees were again classified as to crown position (table 4). The changes over this 5-year period lead to the following statements:

For both species, many trees of all crown classes, both released and control, retrogressed. This was true even of dominant trees; only 60 percent of released dominant yellow-poplar and black cherry were still dominant 5 years after release. The percentages for control dominants were about the same—50 percent of the yellow-poplar and 60 percent of the black cherry stems were still dominant after 5 years. In the 12-year-old stand, 80 to 95 percent of all originally dominant stems were codominant or better.

About 50 percent of the yellow-poplar codominant (original crown positions) were codominant or better after 5 years, with little difference between released and control stems. For codominant black cherry, the figure was about 25 percent, with little difference between released and control stems.

Intermediate trees of both species, both release and control stems, were retrogressing rapidly at 12 years, although current figures indicate that release has retarded this somewhat (table 4). Five to 15 percent of the originally intermediate stems were codominant or better at 5 years.

In general, after 5 years the effects of release on crown position were small and were limited largely to the intermediate crown class which, however, showed no promise of becoming a permanent component of the stand.

Assuming a codominant position as the minimum dominance level acceptable for a potential crop tree in the 12-year-old stand, it appears then that in the 7-year-old stand only dominant trees are good prospects of being codominant or better 5 years later. And because release apparently results in little growth improvement in trees of this crown class, there is little or nothing to be gained by releasing them.

Table 4.—Five-year change in crown class

Crown class before release in 1966	Treatment	Crown class 5 years later								Dead		Dead and overtopped
		Dominant		Codominant		Intermediate		Overtopped				
		No.	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*Pct.*
					YELLOW-POPLAR							
Dominant	Release	12	60	6	30	2	10	0	0	0	0	0
Dominant	Control	10	50	6	30	3	15	1	5	0	0	5
Codominant	Release	1	5	9	45	7	35	2	10	1	5	15
Codominant	Control	4	20	7	35	4	20	2	10	3	15	25
Intermediate	Release	0	0	2	10	7	35	7	35	4	20	55
Intermediate	Control	0	0	1	5	3	15	10	50	6	30	80
					BLACK CHERRY							
Dominant	Release	12	60	7	35	0	0	1	5	0	0	5
Dominant	Control	12	60	5	25	3	15	0	0	0	0	0
Codominant	Release	2	10	2	10	10	50	5	25	1	5	30
Codominant	Control	1	5	4	20	10	50	5	25	0	0	25
Intermediate	Release	0	0	3	15	6	30	10	50	1	5	55
Intermediate	Control	0	0	1	5	1	5	15	75	3	15	90

The 5-year after-release crown-class distribution has several important implications:

1. The lack of consistency from the 7- to 12-year measurement in crown classification of the dominant and codominant controls indicates that at 7 years of age crown position was neither well defined nor stabilized.
2. The rapid overtopping of released intermediates, and to a lesser extent codominants, indicates strongly that many released trees were too short (too young) to stay ahead of the rapid regrowth of sprouts from stems cut in the release operation. We measured a number of such sprouts that had grown over 20 feet in 5 years.
3. Because the effects of release in improving crown position were small and were limited largely to the originally intermediate stems (which are mostly on their way out of the stand), indications are that from now on the released trees will show little or no growth or survival advantages.

The results of this study are somewhat different from the results of a study made on the Pisgah National Forest in North Carolina in 1924. That cleaning, made in an 8-year-old stand, resulted in an improvement in species composition of the upper canopy level that has persisted for 26 years (*Wahlenberg 1950*). Presumably many of the stems released in cleaning were tall enough to stay ahead of sprout regrowth, or perhaps there were other now unassessable differences between the two studies that render invalid comparisons of results.

Effect on Mortality

Five years after the study was begun (when the stand was 12 years old), the intermediate control stems (7-year designation) were dying; 30 percent of the yellow-poplar and 15 percent of the black cherry had already succumbed (table 4), and many trees of both species were barely alive. The release stems of this crown class were dying also but at a slower rate.

Of the stems originally designated codominant, three control trees and two released trees were dead.

All the originally dominant stems of both species were still alive.

Nineteen stems out of a total 240 had died by the time the stand was 12 years old—7 release stems and 12 control stems. Seventeen of these appeared to have succumbed to competition of other woody stems; two appeared to have been killed by grapevines.

Mortality had been somewhat higher among yellow-poplar stems than among black cherry.

Effect on Grapevines

Grapevines do serious damage in hardwood stands on good and excellent sites in the Appalachians. This is particularly true in young even-aged stands where the intolerant vines sprout profusely after the old stand is harvested. Sprouts from cut-off vines grow 5 to 15 feet in length the first growing season after a clearcutting. Mounting in the crowns of young trees, these vines break off limbs and tops, twist and bend over the main stem, augment ice and snow damage, and submerge the tree foliage in large grape leaves and thus interfere with photosynthesis.

The presence of grapevines in sample trees was recorded 5 years after treatment. Three categories of grapevine occurrence were recorded: no grapevine present, grapevine present, and grapevine damage severe (this was a subjective appraisal). Unfortunately, although grapevines were cut out of release trees in the 7-year-old stand, their presence was not recorded at the time for either the release or the control stems.

Five years after the release operation, about two-thirds of the sample trees had grapevines in their crowns (table 5). The situation was the same for both release and control stems, indicating that in most cases the vines had regrown into the release trees after their elimination 5 years previously. Severe grapevine damage was recorded for about ¼ of all sample trees, with a slightly higher incidence for the control stems—from which the grapevines had not been temporarily removed.

With such a high incidence of severe grapevine damage, it would seem that both height and diameter growth would be affected; and

Table 5.—Stems with grapevines

Crown class before release in 1966	Treatment	Stems with grape-vines		Stems with severe grape-vine damage	
		No.	*Pct.*	*No.*	*Pct.*
	YELLOW-POPLAR				
Dominant	Release	15	75	5	25
Dominant	Control	16	80	6	30
Codominant	Release	14	74	4	21
Codominant	Control	14	82	5	29
Intermediate	Release	8	50	2	12
Intermediate	Control	7	50	7	50
	BLACK CHERRY				
Dominant	Release	11	55	4	20
Dominant	Control	11	55	3	15
Codominant	Release	18	95	6	32
Codominant	Control	17	85	8	40
Intermediate	Release	11	58	3	16
Intermediate	Control	4	24	0	0
Average:					
All live stems		146	66	53	24
Release stems		77	68	24	21
Control stems		69	64	29	27

an attempt was made to determine if this were in fact the case. For each class of trees—species crown-class treatment group—5-year height growth and d.b.h. data were compiled separately for trees with and without severe grapevine damage. There were 11 such groups of trees (there would have been 12, but one class had no stems with severe grapevine damage so no comparison was possible). Eight of the 11 groups had greater growth rates—both height and d.b.h.—for the stems without severe grapevine damage (table 6), indicating that this damage adversely affects growth.

In view of the high incidence of grapevines in crop trees—66 percent—we can probably anticipate that a greater proportion of crop trees will suffer severe damage in this stand in the future.

CONCLUSIONS AND DISCUSSION

The analyses made of the biological response of crop trees to release fulfills the primary objective of this research: to determine whether a long-lasting stand improvement will result from a crop-tree release made in a young hardwood stand as soon as the canopy closes and crown classes can be distinguished.

Based on the 5-year study period, indications are that, for yellow-poplar and black cherry on sites like the study site, release at 7 years is too early to permanently improve the crown position of most of the released trees. Because we cannot effect a lasting improvement in crown position, we cannot expect to

Table 6.—Effect of severe grapevine damage on 5-year after-release growth

Dominance class	Treatment	Number of trees: With severe damage	Number of trees: Without severe damage	Height growth: With severe damage	Height growth: Without severe damage	Height growth: Sign. of diff.	Height growth: Damaged trees + or − growth	D.b.h. growth: With severe damage	D.b.h. growth: Without severe damage	D.b.h. growth: Sign. of diff.	D.b.h. growth: Damaged trees + or − growth
		No.	*No.*	*Feet*	*Feet*			*Inches*	*Inches*		
					YELLOW-POPLAR						
Dominant	Release	5	15	11.56	14.13	*	−	1.620	1.875	NS	−
Dominant	Control	6	14	10.38	15.24	*	−	1.367	1.864	NS	−
Codominant	Release	4	15	9.58	12.42	NS	−	.900	1.120	NS	−
Codominant	Control	5	12	8.04	12.87	*	−	.940	1.217	NS	−
Intermediate	Release	2	14	4.35	7.65	NS	−	.250	.607	NS	−
Intermediate	Control	2	12	8.75	6.32	NS	+	.700	.492	NS	+
					BLACK CHERRY						
Dominant	Release	4	16	8.30	13.12	*	−	0.975	1.856	*	−
Dominant	Control	3	17	14.15	12.33	NS	+	1.633	1.600	NS	+
Codominant	Release	6	13	10.25	10.34	NS	−	.833	.954	NS	−
Codominant	Control	8	12	7.36	10.69	*	−	.675	.775	NS	−
Intermediate	Release	3	16	9.63	7.16	NS	+	.933	.544	*	+
Intermediate	Control	0	—	—	—	—	—	—	—	—	—

*Significant at the 5-percent level.

improve species composition or to effect much of a growth increase.

To produce permanent improvement in stands this young would require that the release operations be repeated in a few years, and this would be costly. A better alternative would be to postpone the operation until such a time as the crown classes are more stable and the potential for damage from regrowth of cut grapevines and from sprouts of tree stems cut in the release operation has substantially diminished.

In a previous report about the cost and methodology phases of this study (*Trimble 1971*), a recommendation was made that crop-tree release be postponed until the stand was 9 to 12 years old. If we wait until then, the potential release trees will be taller; and the results of previous research show that thinning in stands of this size brings about stand improvement that persists (*Stoeckler and Arbogast 1947, Conover and Ralston 1959, Drinkwater 1960, and Della-Bianca 1969*).

At this stage, we recommend that, if a crop-tree release is made, it be postponed until crop trees are at least 15 feet tall; and in stands with a high incidence of grapevines, it would be wise to wait until the trees are 25 feet tall.

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★ U.S. GPO: 1973—710-761/210

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