SITE PREPARATION AND WEED CONTROL IN WHITE ASH AND BLACK WALNUT AFFORESTATION

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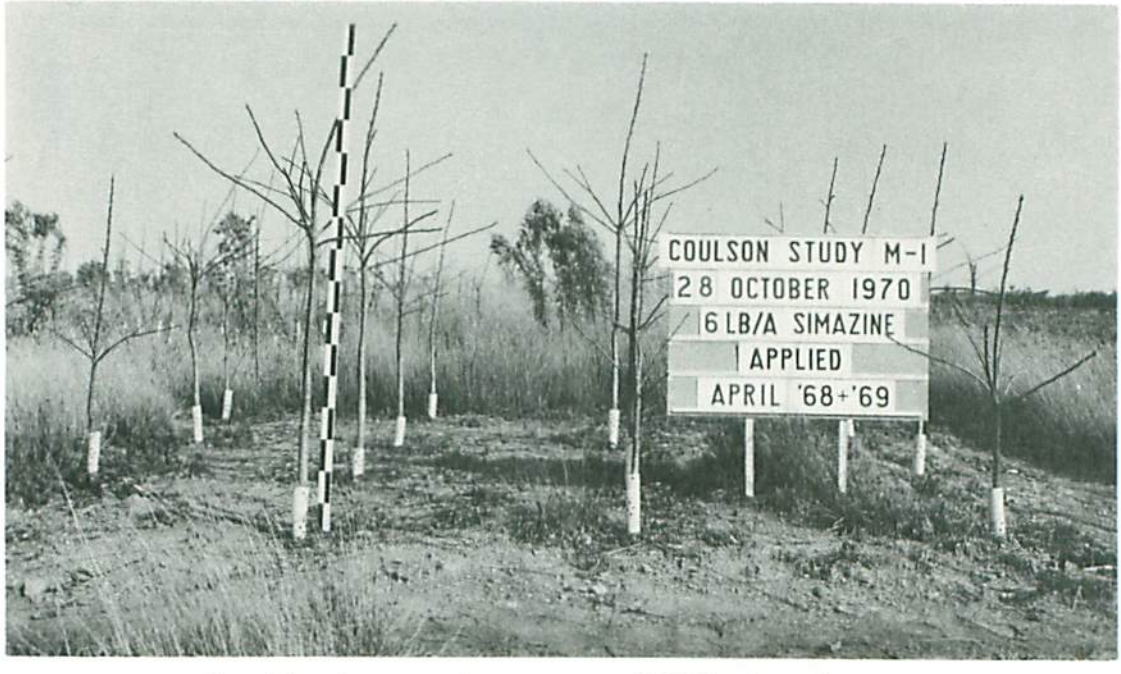

Frontispiece. Three-year-old black walnut.

ABSTRACT

The effects of planting stock age, site preparation, and weed control on survival and height growth of white ash (*Fraxinus americana* L.) and black walnut (*Juglans nigra* L.) were investigated in a factorial experiment near Toronto, Ontario. Cost-benefit relationships of treatments were computed. Three-year height growth of white ash and black walnut was 270 and 235 percent greater, respectively, on plowed and disked ground than in the furrows. Age of planting stock had only a minor effect on tree survival and growth. All simazine treatments provided better weed control than the polyethylene mulch. The highest net return per dollar spent on white ash establishment was obtained by planting 2+0 seedlings in plowed and disked ground and applying two doses of 1.5 pounds/acre of active simazine in subsequent years and for black walnut, by planting 1+0 seedlings in plowed and disked ground and applying two doses of 6 pounds/acre of active simazine in subsequent years.

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INTRODUCTION

Current shortages of high quality hardwood timber together with the growing public awareness of the aesthetic and landscape values of hardwood trees have greatly stimulated the interest in hardwood planting in southern Ontario. White ash (*Fraxinus americana* L.) and black walnut (*Juglans nigra* L.) rank high among desirable afforestation species, because they are valuable timber trees, are aesthically pleasing, and grow well on the medium- to heavy-textured soils common in southern Ontario. Past plantings have met with limited success because of unsuitable sites, poor planting practices, lack of cultivation, mouse girdling, and rabbit browsing (Staley 1970, von Althen 1965). To determine the effects of planting stock age, site preparation, and weed control on the survival and early growth of planted white ash and black walnut, an experiment was set out in the spring of 1968 near Toronto, Ontario.

AREA

The experimental site was a farm field of slightly eroded, imperfectly drained clay loam over reddish clay at a depth of 18 inches. The pH of the plow layer was 6.6 and the organic matter content 2.8 percent. Ground cover consisted of a very vigorous stand of quack grass (*Agropyron repens* (L.) Beauv.), timothy (*Phleum* spp.) goldenrod (*Solidago* spp.), milkweed (*Asclepias* spp.), ragweed (*Ambrosia* spp.), and Canada thistle (*Cirsium arvense* L.).

METHOD

One acre was plowed and disked in autumn 1967. On an adjacent acre, double furrows were plowed in April 1968, each double furrow being 12 inches wide and 3 to 4 inches deep. In each of these two areas, 360 white ash seedlings (2+0) and transplants (2+2), and the same number of black walnut seedlings (1+0) and transplants (1+1) were planted in plots of 12 trees each in a 2 x 2 x 6 factorial arrangement with five replications (Table 1). All trees were planted in the centre of a hole 10 inches in diameter and 18 inches deep, made with a two-man portable power auger.

Immediately after planting, the following weed control treatments were applied: (1) no treatment; (2) mulching with 1.5 mil black polyethylene, 3 feet wide in the plowed and disked portion and 1.5 feet wide in the furrowed portion of the area; (3-6) simazine (wettable powder) applied as a broadcast spray to the plowed and disked ground and in bands 12 inches wide along the furrows, in per acre dosages of 1.5, 3, 4.5, and 6 pounds of active ingredient. The same dosages were applied again in April 1969. To avoid mouse damage, 6-inch-high plastic tree guards were

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Table 1 Size of planting stock

	White ash		Black walnut	
	2+0	2+2	1+0	1+1
Length of stem (in.)[a]	11	21	11	16
Stem caliper 1-in. above root collar (in.)[b]	5/20	8/20	5/20	7/20
Top-root ratio (oven-dry weight)[b]	1:1.1	1:1.9	1:1.2	1:2.4

[a] Average of all trees within each age class.

[b] Samples of 16 trees per species and age class.

placed around all trees shortly after planting.

Effectiveness of weed control was assessed each August by ocular estimate of the density and vigor of competing vegetation (Table 2). Tree survival and height growth were recorded each autumn and the 3-year data were subjected to analysis of variance.

RESULTS

Three-year height growth of white ash and black walnut was 270 and 235 percent greater, respectively, on plowed and disked ground than in the furrows (Table 3). Survival of white ash seedlings and transplants was 18 and 17 percent higher, respectively, in the plowed and disked plots than in the furrows, while black walnut survival was 98+ percent under both site preparation treatments.

Growth of white ash seedlings was 4 inches less than transplant growth in the plowed and disked plots, but 1 inch greater in the furrowed plots. Growth of black walnut seedlings was 1 inch higher than transplant growth in the plowed and disked plots and 4 inches higher in the furrowed plots. Neither species showed any significant differences in survival in regard to age class of planting stock between the plowed and

Table 2 Ocular estimate of weed control by site preparation treatments and years since application

Treatments	Reduction of weed competition					
	Plowed + disked			Furrowed		
	First year %	Second year %	Third year %	First year %	Second year %	Third year %
Control, no treatment	0	0	0	0	0	0
Black polyethylene 3 ft wide	50	30	20	40	40	20
Active simazine 1.5+1.5 lb/ac	50	40	20	60	60	30
Active simazine 3.0+3.0 lb/ac	70	70	40	70	90	60
Active simazine 4.5+4.5 lb/ac	80	90	60	90	90	70
Active simazine 6.0+6.0 lb/ac	90	90	80	90	100	80

Table 3 Effects of site preparation and planting stock age on survival and growth of planted white ash and black walnut

Species and age class	Survival		Height growth	
	Plowed + disked %	Furrowed %	Plowed + disked in.	Furrowed in.
White ash 2+0	82	64	22	7
White ash 2+2	84	67	26	6
Black walnut 1+0	99	98	24	9
Black walnut 1+1	100	99	23	5

Note: Lines connect treatments in which a species showed a significant difference in either survival or height growth at the p.01 level.

disked and the furrowed plots.

All simazine treatments provided better weed control than the polyethylene mulch during all three years of observation, with the 3-, 4.5-, and 6-pound dosages being considerably better (Table 2).

In the plowed and disked plots, the 6-pound dosage of simazine significantly reduced the survival of white ash (Table 4). In the furrowed plots the same was true for all but the 1.5-pound application.

Table 4 Effect of various intensities of weed control on 3-year survival and height growth of planted white ash

Weed control treatments	Survival				Height growth			
	Plowed + disked		Furrowed		Plowed + disked		Furrowed	
	2+0 %	2+2 %	2+0 %	2+2 %	2+0 in.	2+2 in.	2+0 in.	2+2 in.
Control	87	80	75	92	14	17	10	10
Black polyethylene 3 ft wide	88	88	97*	83	27**	30**	11	11
Active simazine 1.5+1.5 lb/ac	95	95*	70	83	22**	33**	5**	5**
Active simazine 3.0+3.0 lb/ac	88	90	58*	60**	25**	27**	5**	2**
Active simazine 4.5+4.5 lb/ac	75*	75	52*	48**	25**	20	9	5**
Active simazine 6.0+6.0 lb/ac	57**	77	32**	36**	19**	30**	4**	0.4**

* Significantly different from control at the p.05 level.

** Significantly different from control at the p.01 level.

Black walnut survival was 95 percent or higher under all treatments (Table 5). In the plowed and disked area, growth of walnut was closely and positively correlated with intensity of weed control (Fig. 1-3). In none of the furrowed plots did growth equal that of the control in the plowed and disked area.

Table 5 Effect of various intensities of weed control on 3-year survival and height growth of planted black walnut

Weed control treatments	Survival				Height growth			
	Plowed + disked		Furrowed		Plowed + disked		Furrowed	
	1+0 %	1+1 %	1+0 %	1+1 %	1+0 in.	1+1 in.	1+0 in.	1+1 in.
Control	98	100	98	98	14	13	6	3
Black polyethylene 3 ft wide	100	100	95	98	27**	23**	4	2
Active simazine 1.5+1.5 lb/ac	95	100	98	97	15	19**	9	4
Active simazine 3.0+3.0 lb/ac	100	100	100	100	23**	27**	10	6
Active simazine 4.5+4.5 lb/ac	100	100	98	100	30**	30**	8	7*
Active simazine 6.0+6.0 lb/ac	100	98	100	100	36**	28**	6	7*

* Significantly different from control at the p.05 level.

** Significantly different from control at the p.01 level.

Figure 1. Three-year growth of black walnut planted in plowed and disked ground without weed control.

Figure 2. Three-year growth of black walnut planted in plowed and disked ground with 3 pounds/acre of active simazine applied in spring of the first and second growing seasons.

Figure 3. Three-year growth of black walnut planted in plowed and disked ground with 6 pounds/acre of active simazine applied in spring of the first and second growing seasons.

ECONOMIC ANALYSIS OF TREATMENTS

All data were computed on the basis of 1 acre planted with 907 trees spaced 8 by 6 feet (Tables 6 and 7). Cost data were calculated as follows: plowing and disking $16.00; furrowing $4.00; planting stock, including production and shipping, 1+0 walnut $8.82/M, 1+1 walnut $40.79/M, 2+0 white ash $16.53/M, and 2+2 white ash $94.81/M; planting of seedlings by wedge method $20.00; planting of transplants with a 10-inch-diameter portable power auger $50.00; polyethylene film applied by hand in 18-inch-wide (furrows) and 3-foot-wide continuous strips over the centre of each row of trees and thereby covering areas of 8,163 and 16,326 feet, respectively, material $28.00 and $56.00, respectively, for the furrowed and plowed and disked areas and labor $70.00 for each; simazine applied in 30 gallons of water/acre over the total area in the plowed and disked plots and in 12-inch-wide bands, spaced 8 feet apart, in the furrowed area and thereby covering 0.125 acre, material $3.50 pound/active ingredient, labor $3.00 and $1.00, respectively, in the plowed and disked and furrowed areas in each of the two years of application.

To obtain a standard comparison relating to differentials in survival and growth of the different treatments, average growth per tree was multiplied by the number of trees per acre (907) and the percent survival for that treatment. To obtain the cost-benefit relationship for each treatment, the net growth of stems in lineal feet/acre was divided by the total cost of establishment.

DISCUSSION

In terms of increased growth of black walnut and increased survival and growth of white ash, plowing and disking were much superior to furrowing. This superiority is based on the following advantages not obtainable by any other site preparation method. Plowing and disking loosen the soil and improve aeration and water infiltration; this treatment destroys all weeds, including the deep-rooted perennial species, and by incorporating this plant material it improves the nutrient status and organic matter content of the soil. It also provides the most favorable conditions for subsequent chemical weed control, because regrowth of weeds can generally be held within acceptable limits by application of herbicides in dosages small enough to be tolerated by susceptible hardwood trees.

Furrowing is much less suitable for hardwood afforestation because it provides only temporary relief from competition, especially on fertile planting sites where competition is always very intense. This short period of relief seldom compensates for the decrease in soil fertility resulting from the removal of the top 3 to 4 inches of soil, and the placement of tree roots in the less fertile subsoil. Other

Table 6 Cost-benefit relationships of treatments used to establish white ash

Age class	Per acre cost of treatments										Net growth/ acre[b]	Net growth/ establishment dollar
	Plowing + disking	Furrowing	Planting stock	Planting	Poly-ethylene	Simazine lb/ac (a.i.)[a]				Total		
						1.5+1.5	3.0+3.0	4.5+4.5	6.0+6.0			
	$	$	$	$	$	$	$	$	$	$	ft	ft
2+0	16	-	15	20	-	-	-	-	-	51	921	18
"	16	-	15	20	126	-	-	-	-	177	1796	10
"	16	-	15	20	-	17	-	-	-	68	1580	23
"	16	-	15	20	-	-	27	-	-	78	1663	21
"	16	-	15	20	-	-	-	37	-	88	1417	16
"	16	-	15	20	-	-	-	-	47	98	819	8
"	-	4	15	20	-	-	-	-	-	39	567	15
"	-	4	15	20	98	-	-	-	-	137	807	6
"	-	4	15	20	-	4	-	-	-	43	265	6
"	-	4	15	20	-	-	5	-	-	44	219	5
"	-	4	15	20	-	-	-	6	-	45	354	8
"	-	4	15	20	-	-	-	-	7	46	97	2
2+2	16	-	86	50	-	-	-	-	-	152	1028	7
"	16	-	86	50	126	-	-	-	-	278	1995	7
"	16	-	86	50	-	17	-	-	-	169	2370	14
"	16	-	86	50	-	-	27	-	-	179	1837	10
"	16	-	86	50	-	-	-	37	-	189	1134	6
"	16	-	86	50	-	-	-	-	47	199	1746	9
"	-	4	86	50	-	-	-	-	-	140	695	5
"	-	4	86	50	98	-	-	-	-	238	690	3
"	-	4	86	50	-	4	-	-	-	144	314	2
"	-	4	86	50	-	-	5	-	-	145	91	0
"	-	4	86	50	-	-	-	6	-	146	181	1
"	-	4	86	50	-	-	-	-	7	147	11	0

[a] Active ingredient.

[b] Net growth/acre = average height growth/tree x percent survival x 907.

Table 7 Cost-benefit relationships of treatments used to establish black walnut

Age class	Per acre cost of treatments										Net growth/ acre[b] ft	Net growth/ establishment dollar ft
	Plowing + disking $	Furrowing $	Planting stock $	Planting $	Polyethylene $	Simazine lb/ac (a.i.)[a] 1.5+1.5 $	3.0+3.0 $	4.5+4.5 $	6.0+6.0 $	Total $		
1+0	16	-	8	20	-	-	-	-	-	44	1036	24
"	16	-	8	20	126	-	-	-	-	170	2041	12
"	16	-	8	20	-	17	-	-	-	61	1081	18
"	16	-	8	20	-	-	27	-	-	71	1735	24
"	16	-	8	20	-	-	-	37	-	81	2265	28
"	16	-	8	20	-	-	-	-	47	91	2721	30
"	-	4	8	20	-	-	-	-	-	32	446	14
"	-	4	8	20	98	-	-	-	-	130	287	2
"	-	4	8	20	-	4	-	-	-	36	665	18
"	-	4	8	20	-	-	5	-	-	37	756	20
"	-	4	8	20	-	-	-	6	-	38	590	16
"	-	4	8	20	-	-	-	-	7	39	454	12
1+1	16	-	37	50	-	-	-	-	-	103	983	10
"	16	-	37	50	126	-	-	-	-	229	1738	8
"	16	-	37	50	-	17	-	-	-	120	1436	12
"	16	-	37	50	-	-	27	-	-	130	2041	16
"	16	-	37	50	-	-	-	37	-	140	2268	16
"	16	-	37	50	-	-	-	-	47	150	2071	14
"	-	4	37	50	-	-	-	-	-	91	219	2
"	-	4	37	50	98	-	-	-	-	189	151	0
"	-	4	37	50	-	4	-	-	-	95	295	3
"	-	4	37	50	-	-	5	-	-	96	454	5
"	-	4	37	50	-	-	-	6	-	97	529	5
"	-	4	37	50	-	-	-	-	7	98	514	5

[a] Active ingredient.

[b] Net growth/acre = average height growth/tree x percent survival x 907.

disadvantages of planting in furrows are the loss of the tree's initial height advantage, and the increased dangers of mouse girdling, flooding, and frost damage. Simazine spraying in combination with furrowing creates additional problems. After heavy rainfalls, simazine accumulates in the bottoms of the furrows, and in this trial it resulted in damage to white ash after application of only 1.5 pounds/acre (active ingredient).

Age of planting stock had only a minor effect on tree survival and growth. Although white ash transplants appeared to be more resistant to simazine than seedlings, survival was only slightly improved. Growth of the white ash transplants was significantly better than seedling growth in the plowed and disked but not the furrowed plots, where growth of both age classes was extremely poor because of intense weed competition, mouse girdling, and simazine damage. This growth advantage of the larger trees was, however, more than offset by their high production costs.

Age of planting stock had no effect on black walnut survival, but seedling growth was significantly better than transplant growth in the furrowed plots and slightly better in the plowed and disked plots. This suggests a superiority of seedling over transplant stock and this is surprising in light of a top-root ratio of 1:1.2 for the seedlings and 1:2.4 for the transplants (Table 1). Additional studies are presently being carried out to determine the effect of planting stock age and size on early survival and growth of various hardwood species.

Effectiveness of weed control was closely correlated with method of site preparation and intensity of simazine application. Black polyethylene mulch controlled weed growth nearly as effectively as two applications of 1.5 pounds/acre of active simazine but much less effective than higher dosages of simazine. Two applications of 3, 4.5, and 6 pounds/acre of active simazine, applied in successive years, provided satisfactory to excellent weed control on both the plowed and disked and the furrowed plots. However, on the latter area, vigorous weed growth on either side of the furrows created a tunnel effect which seriously impeded tree growth. Simazine application in bands wider than the furrows might prevent the tunnel effect, but this treatment will greatly increase the danger of simazine seeping or washing into the furrows and causing damage.

Although the control of competing vegetation was the main purpose for the application of polyethylene mulch and simazine, the following additional benefits might be derived from these treatments and probably also contributed to improved tree growth. Covering the soil with polyethylene reduces surface evaporation (Gabriel 1962), soil temperature extremes (Waggoner *et al.* 1960), and the rate of nitrate leaching (Clarkson 1960), while simazine has been found to improve the nitrogen nutrition of fruit trees (Ries *et al.* 1963) and accelerate the rate of protein accumulation in rye and peas (Ries *et al.* 1967).

The tree guards which were placed around all trees had little effect on the degree of mouse damage. Where weed growth was controlled, no mouse damage occurred even under heavy snow. But in heavy sod, mice either girdled the trees above the tree guards or tunnelled under them. We cut our tree guards in half since most trees were too small for the full 12-inch guards. Longer tree guards might have prevented girdling from above, but not from below. In our experience the only effective protection against mouse damage is the elimination of weeds.

While growth responses are the most important indicators of the effects of various experimental treatments, practical application of the results will largely depend on the cost-benefit relationships. The highest net return per dollar spent on white ash establishment was obtained by planting 2+0 seedlings in plowed and disked ground and applying two doses of 1.5 pounds/acre of active simazine in subsequent years (Table 6). The next best treatments were application of 3.0 pounds/acre of active simazine and no weed control. The highest return per dollar spent on the establishment of black walnut was obtained by planting 1+0 seedlings in plowed and disked ground and applying two doses of 6 pounds/acre of active simazine in subsequent years. The next best treatments were two applications of 4.5 or 3.0 pounds/acre of active simazine.

Similar growth performances of transplants and seedlings, but much higher production costs for the transplant stock make the use of transplants rather uneconomical in forest plantations. The poor growth of both species planted in furrows shows that furrowing is an unsuitable site preparation method for the afforestation of white ash and black walnut in weed-infested clay loam soils.

CONCLUSIONS

On the basis of these results, white ash and black walnut afforestation is recommended in southern Ontario subject to the following conditions.

1. A well- to moderately well-drained planting site with at least 18 inches of topsoil and sufficient fertility to produce a fair farm crop.

2. Deep plowing of the total plantation area in the early summer preceding spring planting.

3. Disking shortly after plowing and again in late August to eliminate all new weed growth.

4. Spade or machine planting of sturdy seedlings in early spring.

5. Broadcast application, shortly after planting, of 3 and 6 pounds/acre of active simazine, respectively, in white ash and black walnut plantations, followed by a second application of equal intensity in early spring of the second year.

6. A weed-free border at least 15 feet, wide to prevent mouse damage to border trees.

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