

WEED CONTROL WITH SIMAZINE
REVITALIZES GROWTH IN
STAGNATING HARDWOOD PLANTATIONS

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ABSTRACT

Three studies were carried out near Thedford and Hornby in southern Ontario to determine the effectiveness of simazine applications in revitalizing the growth of stagnating red oak (*Quercus rubra* L.), black walnut (*Juglans nigra* L.), basswood (*Tilia americana* L.), and white ash (*Fraxinus americana* L.) plantations. With few exceptions, dosages of 3.4-9.0 kg/ha (3-8 lb/acre) of active simazine, applied in two successive years 5 to 8 years after planting, significantly increased the height growth of all treated trees. Soil moisture was much lower in soils supporting dense weed growth than in soils without weeds. Nitrogen concentrations were higher in the leaves of trees growing in the treated, weed-free plots than in the untreated, weed-infested plots.

RÉSUMÉ

Aux environs de Thedford et Hornby, dans l'Ontario sud, on a mené trois études afin de déterminer l'efficacité des applications de simazine pour revigorer la croissance stagnante dans des plantations de Chêne rouge (*Quercus rubra* L.) de Noyer noir (*Juglans nigra* L.), de Tilleul d'Amérique (*Tilia americana* L.) et de Frêne blanc (*Fraxinus americana* L.). A peu d'exceptions près, des dosages de 3.4 à 9.0 kg/ha (3 à 8 lb/acre) de simazine active, appliquée deux années de suite entre les 5^e et 8^e années après le plantage, augmentèrent significativement la croissance en hauteur chez tous les arbres traités. La teneur en humidité était beaucoup moindre dans les sols où poussaient densément les herbes indésirables que dans les sols dépourvus de ces herbes. Les concentrations d'azote furent plus élevées dans les feuilles des arbres des parcelles traitées, sans herbes nuisibles, que parmi les parcelles non-traitées, infestées d'herbes indésirables.



Frontispiece. Black walnut plantation with good weed control.

INTRODUCTION

The importance of weed control in the successful establishment of hardwood plantations is well documented (Wallihan 1949, Limstrom 1963, von Althen 1965) and many recommendations have been made for effective weed control (Byrnes 1966, Erdmann 1967, von Althen 1972a). These recommendations generally have specified partial or total elimination of the competing vegetation during the first 1-3 years after planting. After 3 years most hardwood species planted in fertile soils are expected to be able to outgrow the competing vegetation without application of further weed control treatments. Unfortunately this does not always happen. Be it the result of site conditions, poor planting practices, or less than adequate weed control during the early years after planting, the planted seedlings are often unable to maintain their growth after the weed control treatments are discontinued. The result generally is a prolonged period of stagnation when height growth averages only a few cm per year instead of the 30-120 cm (1-4 ft) expected on good sites (Krajicek and Williams 1971).

To determine the effectiveness of weed control treatments, applied several years after the original treatments had been suspended, in revitalizing seedling growth, different dosages of simazine were applied to three plantations. These plantations had been established 6-9 years previously to test the effects of age of planting stock, planting method, and weed control on the survival and growth of hardwood seedlings and transplants. The effects of the original and the secondary treatments on seedling and transplant survival and growth are reported here.

METHOD

Study 1

The study area, a former field near Thedford, Middlesex County, Ontario, has a deep, moderately well-drained, fine sandy loam soil of the Ontario Soil Survey Fox Series. The pH of the plow layer is 6.8 and the organic matter content is 2.8%.

The total experimental area was plowed and disked in the autumn prior to spring planting. In the spring of 1968, red oak (*Quercus rubra* L.) seedlings and transplants were planted by spade and auger at a spacing of 91 x 91 cm (3 x 3 ft).

The study was laid out in a factorial arrangement with 16 seedlings and transplants planted by spade and auger in each of five weed control treatments (Table 1). Each treatment was replicated four times for a total of 640 seedlings and transplants.

Table 1. Comparison of original and secondary treatments by studies.

Study No.	Species	Factors in original experiments				Date of application and dosage of secondary weed control treatments
		Age of planting stock	Planting method	Date of application and dosage of original weed control treatments		
1.	Red oak	1. 2+0 2. 2+2	1. spade 2. auger	Shortly after planting	April of 2nd year	April of 6th and 7th year after planting 1. Two replications - no treatments 2. Two replications - simazine 6.7 kg/ha
				1. control	1. -	
				2. mulched with black polyethylene film	2. -	
				3. simazine 2.2 kg/ha	3. simazine 1.1 kg/ha	
				4. " 4.5 " "	4. " 2.2 " "	
2.	Black walnut	1. 1+0 2. 1+1	auger	Shortly after planting	Shortly after planting	April of 7th and 8th year after planting 1. Two replications - no treatments 2. Two replications - simazine 9.0 kg/ha
				1. control	1. -	
				2. mulched with black polyethylene film	2. -	
				3. simazine 1.7 kg/ha	3. simazine 1.7 kg/ha	
				4. " 3.4 " "	4. " 3.4 " "	
3.	Black walnut	1+0	spade	Autumn before spring planting	no treatment	April of 5th and 6th year after planting 1. control 2. simazine 1.7 kg/ha 3. " 3.4 " " 4. " 5.0 " " 5. " 6.7 " "
				1. control		
				2. pronamide (wetable powder) 1.7 kg/ha		
				3. pronamide (granular) 1.7 kg/ha		
				April, shortly before planting		
White ash	2+0		4. pronamide (wetable powder) 1.7 kg/ha			
			5. pronamide (granular) 1.7 kg/ha			
Basswood	2+0					

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When growth slowed owing to what was believed to have been intense competition from mainly quackgrass (*Agropyron repens* [L.] Beauv.), wild carrot (*Daucus carota* L.), and goldenrod (*Solidago* spp.), 6.7 kg/ha (6 lb/acre) of active simazine (Princep 80W®) were broadcast over two replications in April of 1973 and 1974 (the sixth and seventh years after planting) while the other two replications received no applications.

Foliage samples were collected on July 15 and 29 and August 16, 1974 and were analyzed for N, P, K, Ca, and Mg content. Soil samples were collected on July 15 and 29 and percent soil moisture was determined.

Tree survival and height were recorded in autumn of each of the 9 years after planting and the 3-year and 9-year data were subjected to analyses of variance and Duncan's New Multiple Range Test (Steel and Torrie 1960).

Study 2

The study area, a former field near Hornby, Halton County, Ontario has a slightly eroded, imperfectly drained clay loam soil of the Ontario Soil Survey Chinguacousy Series. The pH of the plow layer is 6.6 and the organic matter content 2.8%.

The total experimental area was plowed and disked in the autumn prior to spring planting. In the spring of 1968, black walnut (*Juglans nigra* L.) seedlings and transplants were planted in holes made with a 10-in. (25.4 cm) diameter soil auger at a spacing of 150 x 150 cm (5 x 5 ft).

The study was laid out in a factorial arrangement with 12 seedlings and transplants in each of six weed control treatments (Table 1). Each treatment was replicated four times for a total of 288 seedlings and transplants.

When growth slowed owing to what was believed to have been intense competition from mainly quackgrass, goldenrod and Canada thistle (*Cirsium arvense* [L.] Scop.) 9.0 kg/ha (8.0 lb/acre) of active simazine were broadcast over two replications in April of 1974 and 1975 (the seventh and eighth growing seasons) while the other two replications received no applications.

Foliage samples were collected in August 1974 and 1975 from trees growing in the untreated and herbicide-treated plots and were analyzed for their N, P, K, Ca, and Mg content.

Tree survival and height growth were recorded each autumn for the first 3 years and in the eighth year after planting, and the 3-year and 8-year data were subjected to analyses of variance and Duncan's New Multiple Range Test.

Study 3

The study was carried out in the same field as Study 2 with the same soil conditions as those described under Study 2. Ground cover was mainly dense quackgrass, timothy (*Phleum pratense* L.), goldenrod, and wild aster (*Aster* spp.).

Pronamide (Kerb) was applied either in November, 1970 or at the beginning of April, 1971 (Table 1). At the end of April, 1971 12 black walnut, white ash (*Fraxinus americana* L.), and basswood (*Tilia americana* L.) seedlings were planted by spade in each treatment plot at a spacing of 91 x 91 cm (3 x 3 ft). The study was laid out in a randomized block arrangement with 12 trees of three species in each of five weed control treatments. Each treatment was replicated four times for a total of 240 seedlings per species.

In April of 1975 and 1976 (the fifth and sixth years after planting) different dosages of simazine were broadcast over the original pronamide plots.

Seedling survival and height were recorded in the autumn of years 1, 2, 4 and 6 after planting and the second, fourth and sixth year data were subjected to analyses of variance and Duncan's Multiple Range Test.

RESULTS

Study 1

The third year results of this study have been reported previously (von Althen 1972b). To review briefly: age of planting stock and planting method had no significant effects on seedling or transplant survival or growth. Weed control significantly increased the height growth of seedlings in treatment 4 and 5 and that of transplants in treatments 3, 4, and 5.

After nine growing seasons and the application of the secondary weed control treatments survival of seedlings and transplants was 74% or better under all treatments with no significant differences between any of the original or secondary treatments. Planting method had no significant effect on height growth. Average height of the seedlings

and transplants was 282 cm (9.3 ft) and 347 cm (11.4 ft), respectively. Since 25 cm (10 in.) of this difference was due to the larger size of the transplants at time of planting, height growth of seedlings and transplants was not significantly different.

Seedling and transplant heights were closely correlated with the effectiveness of the original and secondary weed control treatments. Not only were the effects of the original weed control treatments (applied in the first and second years after planting) still very apparent after nine growing seasons, but the secondary simazine applications in the sixth and seventh growing seasons significantly increased the growth of all treated trees (Fig. 1).

The results of the foliar analyses show that the N content was higher in the leaves of trees growing in the treated areas, while the K and Ca contents were higher in the leaves of trees growing in the untreated, weed-infested areas (Table 2).

The results of the moisture determinations show that soil moisture was much lower in the soil supporting a dense cover of weeds (untreated plots) than in the soil with no weeds (treated plots) (Fig. 2).

Study 2

The third-year results of this study have been reported previously (von Althen 1971). To review briefly: survival was 95% or better under all treatments. Age of planting stock had no effect on survival or height growth. Height growth was closely and positively correlated with intensity of weed control. With the exception of the seedlings in treatment 3 (simazine applied at 1.65 kg/ha) height growth under all treatments was highly significantly better than that of the control.

After eight growing seasons and the application of the secondary weed control treatments survival was 90% or better under all treatments with no significant differences between any of the original or secondary treatments. Age of planting stock had no significant effect on survival or height growth. Height of seedlings and transplants was no longer correlated with the original weed control treatments applied in the first and second years after planting. Height of seedlings and transplants was, however, significantly better in all plots treated with simazine in the seventh and eighth years after planting than in those plots which had received no weed control in the seventh and eighth years (Fig. 3 and 4). Analysis of the foliage samples collected in August of 1975 and 1976 showed that nitrogen concentrations were higher in the leaves collected from trees growing in the treated, weed-free plots while Ca and Mg concentrations were higher in the leaves collected from trees growing in the untreated, weed-infested plots (Table 3).

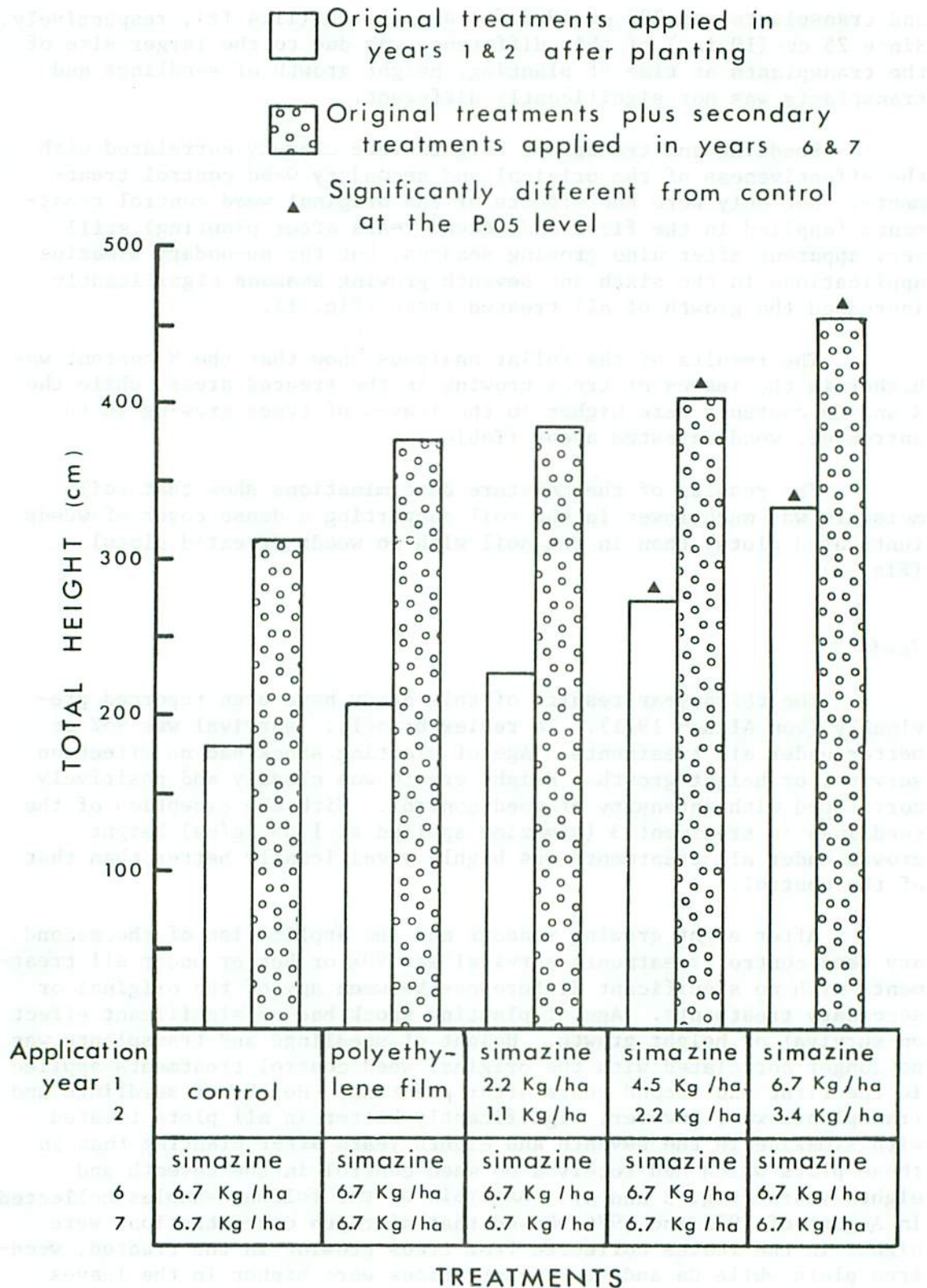


Figure 1. Height of red oak seedlings and transplants by weed control treatments 9 years after planting.

Table 2. Study 1. N, P, K, Ca, and Mg concentrations in red oak leaves collected from trees in weed-infested plots and in those treated with simazine

Date of collection	Untreated, dense weed cover					Simazine-treated, nearly weed-free				
	N	P	K (%)	Ca	Mg	N	P	K (%)	Ca	Mg
15 July	2.1	.12	.79	.82	.26	2.72	.13	.70	.82	.25
29 July	1.95	.12	.79	.94	.29	2.79	.12	.69	.80	.26
16 August	1.80	.12	.84	.97	.29	2.42	.12	.66	.88	.26

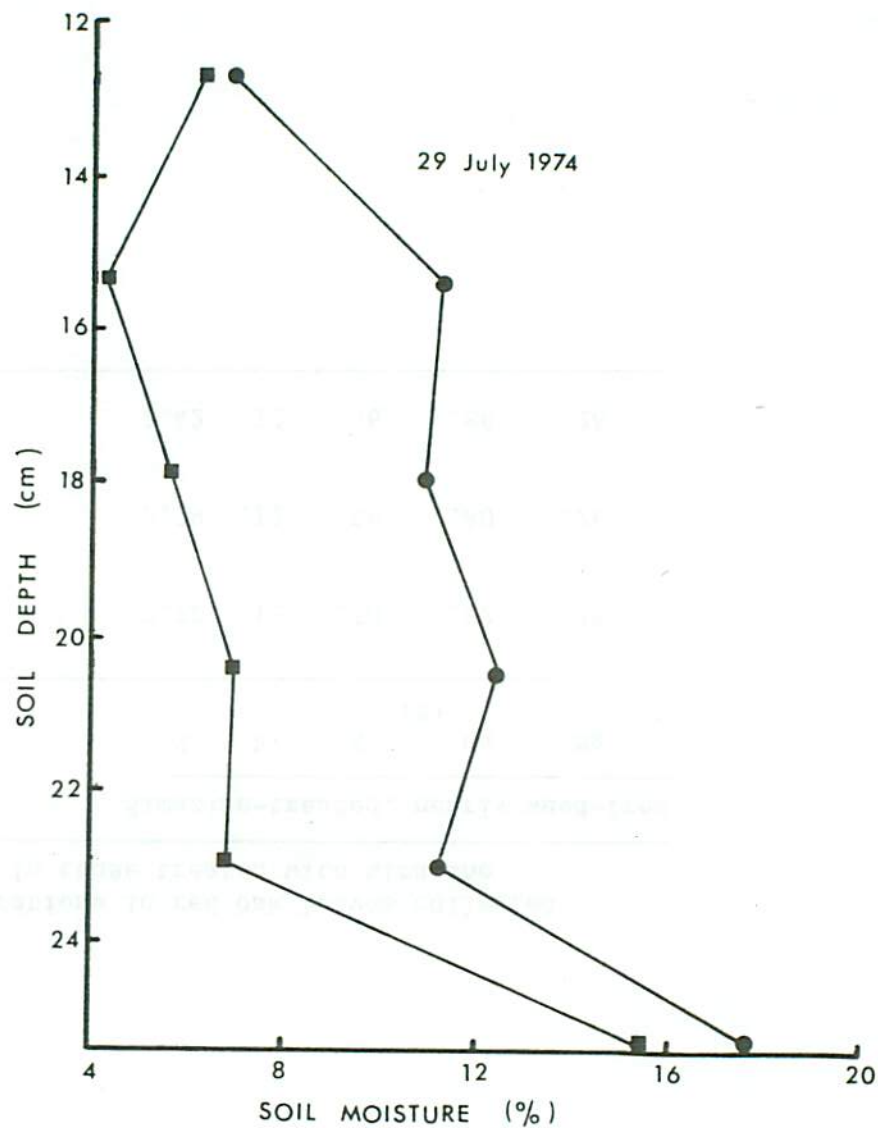
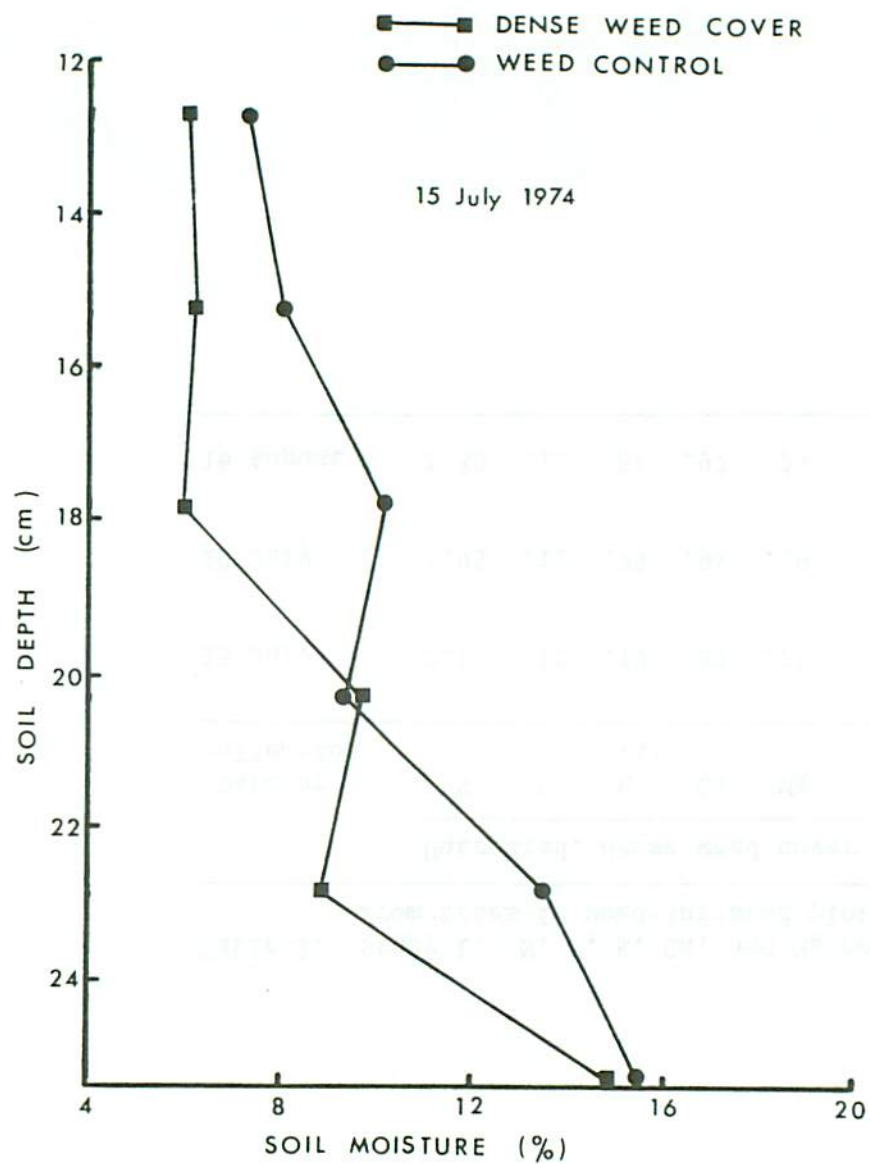


Figure 2. Percent soil moisture in a red oak plantation with and without weed control.

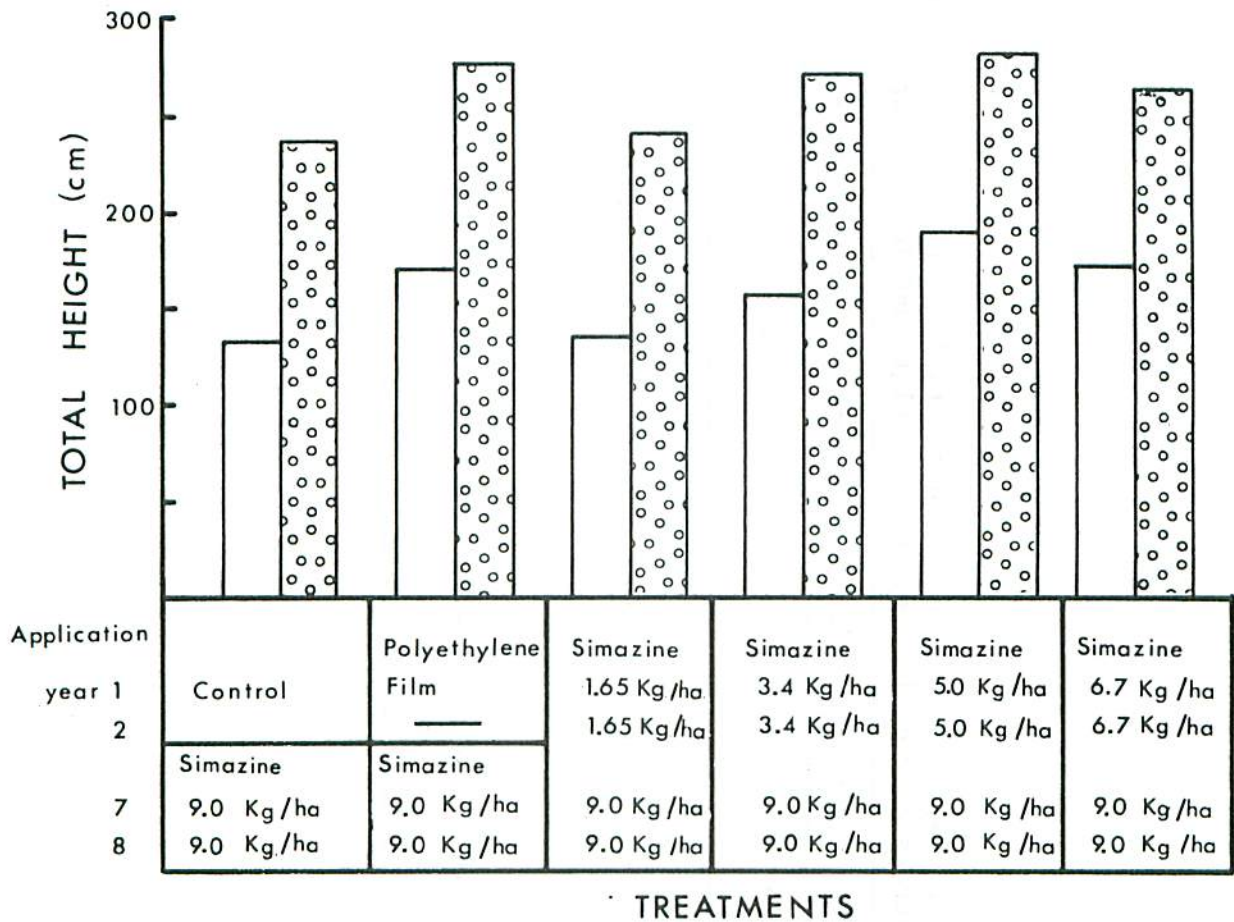
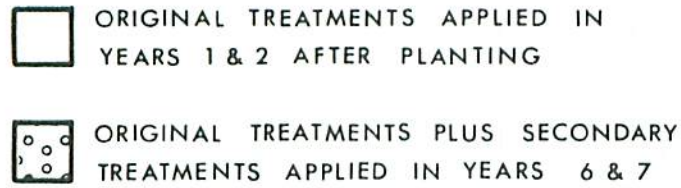


Figure 3. Height of black walnut seedlings and transplants, by weed control treatment, 8 years after planting.

Table 3. Study 2. N, P, K, Ca, and Mg concentrations in black walnut leaves collected from trees growing in weed-infested plots and in those treated with simazine

Date of collection	Untreated, dense weed cover					Simazine-treated, nearly weed-free				
	N	P	K (%)	Ca	Mg	N	P	K (%)	Ca	Mg
August 1974	1.76	.26	1.19	2.42	.44	2.39	.28	1.29	1.78	.33
August 1975	1.78	.27	1.22	2.12	.54	2.62	.30	1.24	1.64	.37



Figure 4. Study 2. Walnut plantation 8 years after planting. On the right with weed control, on the left without weed control.

Study 3

Survival of all three species at 2, 4, and 6 years after planting showed no significant difference between treatments (Table 4). Heights of the three species did not differ significantly between treatments at 2 and 4 years after planting (Fig. 5). However, following the applications of simazine in the fifth and sixth years after planting, the height of all three species increased significantly. Heights of the basswood seedlings were significantly higher than those of the control in treatments 3, 4, and 5. Heights of the white ash seedlings were significantly higher than those of the control in treatments 2, 3, and 5 (Fig. 6 and 7), while heights of the black walnut seedlings were significantly higher than those of the control in treatment 5.

The original pronamide (Kerb) applications significantly reduced the grass cover but in its place a dense cover of broadleaved weeds became established. The lowest dosage (1.7 kg/ha of active simazine, or 1.5 lb/acre) reduced the density of the weed cover by approximately 30%. No injury to any of the tree seedlings was observed

Table 4. Study 3. Survival of black walnut, white ash, and basswood seedlings by treatments and years since planting

Treatment	Black walnut			White ash			Basswood		
	2 yr after plan- ting	4 yr after plan- ting	6 yr after plan- ting	2 yr after plan- ting	4 yr after plan- ting	6 yr after plan- ting	2 yr after plan- ting	4 yr after plan- ting	6 yr after plan- ting
	%	%	%	%	%	%	%	%	%
1	80	58	50	93	93	93	85	72	72
2	78	66	65	100	100	97	90	71	70
3	85	71	63	100	98	97	98	73	72
4	81	75	75	98	96	93	91	86	77
5	71	65	65	100	96	96	96	63	63

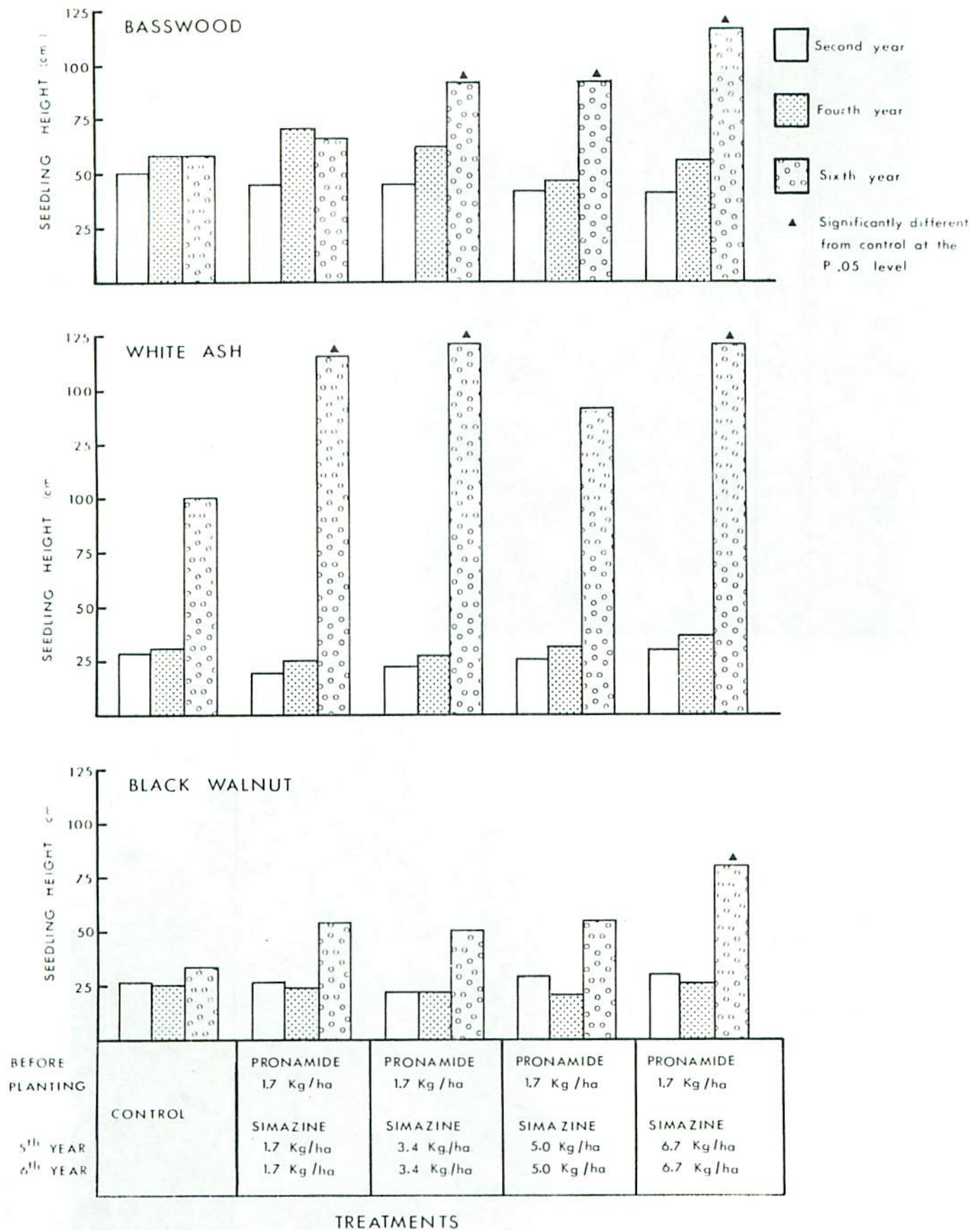


Figure 5. Height of basswood, white ash, and black walnut seedlings, by treatment and years since planting.



Figure 6

Study 3. White ash seedlings
6 years after planting without
weed control.



Figure 7

Study 3. White ash plantation
6 years after planting and
applications of 5 kg/ha of
simazine in April of the 5th
and 6th year after planting.

at this rate of application. The highest dosage (6.7 kg/ha of active simazine, or 6.0 lb/acre) reduced weed competition by 90% with only a few clumps of the well established goldenrod surviving. However, this dosage caused brown leaf margins and yellowing of the leaves in 20% of the white ash seedlings. Nevertheless, no white ash seedlings were killed and most seedlings resumed growth in July. The 3.4 and 5.0 kg/ha (3 and 4.5 lb/acre) dosages of active simazine reduced weed competition by approximately 50 and 70%, respectively, without injury to the seedlings of any of the three species.

DISCUSSION AND CONCLUSIONS

On fertile sites, competition from grasses and broadleaved weeds appears to be the main cause of unsatisfactory growth of planted hardwood seedlings or transplants. A dense cover of herbaceous plants may adversely influence the survival and growth of young hardwood trees by: (1) providing intense competition for soil moisture, nutrients, and soil oxygen; (2) providing an ideal habitat for rabbits and mice which may browse or girdle the trees; and (3) excreting substances which may have a toxic effect on the root growth of the planted trees.

While many studies have shown that removal of the competing vegetation is a prerequisite to satisfactory hardwood plantation establishment and early growth (Pruett and Gatherum 1961, Yawney and Carl 1970, von Althen 1971, Webb 1974, Bey et al. 1975), information is lacking at present on plantation development following the first few years of intensive weed control. Some plantations continue to grow well after the weed control treatments have been discontinued, while trees in other plantations are unable to maintain their growth rate and slowly slide into a prolonged state of stagnation. During the period of stagnation these seedlings are exposed to disfiguration or death from browsing by rabbits and girdling by mice or to smothering by the leaves and dead stems of the herbaceous vegetation.

Any one or a combination of the following factors is probably responsible for the stagnation of most hardwood plantations: (1) the seedlings or transplants may have been planted on a site unsuitable for the species and, although initial growth was satisfactory, the rate of growth could not be maintained; (2) weed control during the first few years after planting was inadequate so that the young trees were severely handicapped in their struggle for domination of the competing vegetation; (3) the weed control treatments were discontinued too soon so that a new, dense weed cover could become established before the planted trees were large enough to compete successfully; (4) spacing between the trees was so wide that the trees were unable to close the canopy quickly enough to shade out the competition after the weed control treatments were discontinued.

The first indication of the onset of stagnation is generally the yellowing of leaves in early summer. While the leaves of fast-growing trees maintain their dark green color until late summer, leaves of trees growing under stress turn yellow as early as the end of June. In the red oak plantation described in Study 1, the leaf color of the trees in the untreated, weed-infested plots was yellowish-green (5 GY 5/8 Munsell color charts for plant tissues, Baltimore) in the middle of July, while that of the trees growing in the treated plots was dark green (5 GY 3/4). In the walnut plantation described in Study 2, the leaf color of the trees growing in the weed-infested plots was yellowish green (2.5 GY 6/8) in the middle of August, while that of the trees growing in the treated plots was dark green (5 GY 4/4).

Nutrition of the seedlings and transplants was strongly influenced by weed control (Tables 2 & 3). The N concentrations in the red oak and black walnut leaves were substantially and consistently higher in the treated than in the untreated plots. The P concentrations were nearly equal in the treated and untreated plots while the K, Ca and Mg concentrations in the red oak and the Ca and Mg concentrations in the black walnut leaves were slightly higher in trees growing in the untreated, weed-infested plots. The reasons for the differences in K, Ca, and Mg concentrations are not fully understood, but they are most likely the result of the dilution effect (Armson 1973).

Comparison of the N concentrations in the leaves of the trees growing in the treated plots with results obtained from fertilizer experiments carried out on the same sites reveals that the N concentrations in the red oak leaves were average while those in the black walnut leaves were slightly below average (von Althen 1976). Of course, in all weed-infested plots the concentrations were substantially below average. It may therefore be argued that nutrition is the most important factor affecting seedling growth in weed-infested plots (Sutton 1975).

However, lack of available soil moisture may have an equal or greater effect than nutrient deficiency on the growth of seedlings and transplants in weed-infested plots (Webb 1974). While Geiger (1966) showed that water loss is usually higher from soil supporting vegetation than from bare soil, Lane and McComb (1948) proved that brome grass (*Bromus inermis* Leyss.) reduced the available soil moisture more rapidly than did either black-locust (*Robinia pseudoacacia* L.) or green ash (*Fraxinus pennsylvanica* var. *subintegerrima* [Vahl] Fern.) seedlings and that this rapid depletion decreased top growth and increased mortality of the tree seedlings.

In southwestern Ontario the average rainfall during June, July, and August is 208 mm (8.2 in.) (Putman and Chapman 1938). While in normal years this rainfall is fairly equally distributed over the months, large variations do occur which put great moisture stress

on all trees and especially on recently planted seedlings. Such an unequal distribution occurred in July, 1966 when only 14 mm (0.55 in.) of rain fell near Hornby: the normal precipitation for the month was 70 mm (2.74 in.) (Anon. 1966). Probably of equal importance, however, is the amount of precipitation which falls during any single rainstorm. When the rainfall is very light much of the moisture is intercepted by the vegetation and the remainder is absorbed by the roots growing near the soil surface. In heavy rainstorms much of the precipitation is lost to the vegetation in runoff. The soil moisture data of Study 1 show that the available soil moisture in the weed-infested plots was so low it probably induced severe moisture stress in the red oak trees.

A cover of dense herbaceous vegetation also provides an ideal habitat for rodents (Radvanyi 1974). In the red oak plantation described in Study 1 rabbits removed the bark from the stems and lower branches of the smallest trees while the larger trees were not attacked, presumably because the bark of these trees was less palatable. Since there were only a few small trees present in the treated plots, damage in these plots was negligible. It is probable that rabbits would not have attacked trees in the treated plots had these not been interspaced with untreated, weed-infested controls.

In the red oak and black walnut plantations of Studies 1 and 2, damage from stem girdling by mice was very light after 7 years. In Study 3, 96% of the white ash, 83% of the basswood and 22% of the black walnut seedlings were girdled or partially girdled by mice during the first 4 years after planting. However, following the weed control treatments in the fifth and sixth years after planting, girdling damage was restricted to trees growing in the untreated plots or near clumps of weeds that had survived the light herbicide treatments. Since it has been noted in other plantations that white ash seedlings are generally more severely girdled than basswood seedlings and that walnut seedlings generally sustain the least damage, it is suggested that meadow voles (*Microtus pennsylvanicus*) have definite feeding preferences with respect to tree species and seedling ages.

In the red oak plantation of Study 1 the effectiveness of the weed control treatments, applied in the first 2 years after planting, was still very apparent 9 years after planting (Fig. 1). In the plots which had received the two highest dosages of simazine, trees were significantly taller than those in the controls. This shows the importance of effective weed control during the early years after planting.

However, in the walnut plantation of Study 2 the effects of the weed control treatments applied in the first 2 years after planting had largely disappeared 8 years after planting. One

explanation for this development is that the weed control treatments were suspended too soon. This allowed the establishment of a dense weed cover before the trees were able to maintain their growth rate and thereby outgrow the competition. This would also explain the similar response of all trees in all treatments to the simazine applications in the seventh and eighth years after planting. Since all trees in all plots suffered from severe competition, nearly all trees regardless of the original treatments responded equally well to the release.

On the basis of the results of Study 2 it might be suggested that all weed control could have been delayed until the seventh year after planting without great loss of seedling or transplant growth. However, as shown by the results of Study 3, where simazine was not applied until the fifth year after planting, both survival and height growth may suffer from such an approach.

The results of all three studies provide a good indication of the great recuperative capacity of red oak, black walnut, basswood, and white ash seedlings. Following several years of intense competition from grasses and forbs nearly all trees responded to the weed control treatments with greatly increased growth.

The results of these studies are important to forest managers and plantation owners because they show what can be done to increase growth in slow-growing hardwood plantations.

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