SITE PREPARATION AND POST-PLANTING WEED CONTROL IN HARDWOOD AFFORESTATION: WHITE ASH, BLACK WALNUT, BASSWOOD, SILVER MAPLE, HYBRID POPLAR

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ABSTRACT

This report presents the five-year results of studies on the effects of site preparation and post-planting weed control on the survival and growth of planted 1+0 black walnut (*Juglans nigra* L.), 2+0 basswood (*Tilia americana* L.), 2+0 white ash (*Fraxinus americana* L.), 2+0 silver maple (*Acer saccharinum* L.) and cuttings of the hybrid poplar clone I 45/51 (P x euramericana, Italy). The planting site was a former agricultural field with an imperfectly drained clay loam soil which had been afforested in 1961 with white pine (*Pinus strobus* L.) and white spruce (*Picea glauca* [Moench] Voss). By 1974 the majority of these trees had succumbed to weed competition and mouse girdling.

All hardwood seedlings were planted by machine and the cuttings were planted with a dibble in the spring of 1976. Site preparation treatments consisted of plowing and disking one part of the area in its entirety and broadcast application of Kerb®, plowing and disking strips of different widths to one side or from either side to the middle, rototilling or spraying a strip with Gramoxone®, and a control. Post-planting weed control consisted of applications of Princep® shortly after planting and in April of the next two years over the total area plowed and disked in its entirety, or applied in strips of different widths over the plowed and disked, rototilled and Gramoxone® strips and the control.

The experiment was laid out in a randomized block design with 12 seedlings or cuttings per species in each of eight treatments replicated three times for a total of 288 seedlings or cuttings per species. Survival and growth were monitored for five years and the five-year survival data were subjected to χ^2 tests of independence while the five-year height data were subjected to an analysis of variance and Tukey's test of significance.

Survival of basswood and black walnut was 86 percent or better under all treatments. White ash and silver maple survival was significantly lower in the control than in all other treatments. All hybrid poplar cuttings died in the control plots and only 8% survived in the Gramoxone® plots.

Height growth of all species was highest in the area which had been plowed and disked in its entirety and then subjected to broadcast applications of Kerb® and Princep®. Neither rototilling nor plowing of furrows to one side, or from either side to the middle, had much effect on growth, but the wider the strip that was plowed, the better the growth.

Recommendations are made for the successful establishment of black walnut, white ash, basswood, and silver maple seedlings and hybrid poplar cuttings on old field sites in southern Ontario.

RÉSUMÉ

Ce rapport présente les résultats de cinq années d'études sur les effets de la préparation d'une station et de la lutte aux mauvaises herbes après plantage sur la survie et la croissance de semis 1+0 du Noyer noir (*Juglans nigra*), 2+0 du Tilleul d'Amérique (*Tilia americana* L.), 2+0 du Frêne blanc (*Fraxinus americana* L.), 2+0 de l'Érable argenté (*Acer saccharinum* L.) plantés et sur les boutures du clône de Peuplier hybride I 45/51 (P x euramericana, d'Italie). La station était un ancien champ agricole ayant un sol de limon sablonneux mal drainé qui avait été reboisé en 1961 avec le Pin blanc (*Pinus strobus* L.) et l'Épinette blanche (*Picea glauca* [Moench] Voss). En 1974, la plupart de ces arbres avaient succombé à la concurrence des mauvaises herbes et à l'annélation par les souris.

Tous les semis de feuillus avaient été plantés à la machine et les boutures avaient été plantées avec un plantoir manuel au printemps 1976. La préparation de la station avait consisté à sillonner et labourer une partie du secteur entier et à épandre du Kerb® à la volée, en sillonnant et labourant des bandes de différentes largeurs, sur un côté ou l'autre vers le milieu, à passer le motoculteur ou à arroser une bande avec du Gramoxone®, puis le traitement témoin. La lutte aux mauvaises herbes après le plantage comprenait des applications de Princep® peu après le plantage et en avril des deux années suivantes, une application sur toute la superficie labourée et sillonnée dans son entier ou par bandes de diverses largeurs de Gramoxone® suivie du traitement témoin.

L'expérience a eu lieu dans un bloc randomisé avec 12 semis ou boutures par essence pour chacun des huit traitements répétés trois fois, soit un total de 288 semis ou boutures par essence. On a suivi de près la survie et la croissance durant cinq ans et les données sur la survie au terme des cinq années ont été soumises à des tests d'indépendance au χ^2 tandis que les données sur la hauteur atteinte au bout de cinq années étaient soumises à une analyse de variance et au test de signification de Tukey.

La survie du Tilleul et du Noyer noir s'est élevée à 86% ou mieux pour tous les traitements. Le Frêne blanc et l'Érable argenté ont eu un taux de survie significativement plus faible dans le traitement témoin que dans tous les autres traitements. Toutes les boutures de Peuplier hybride sont mortes dans les placettes témoins et la survie n'a été que de 8% dans les placettes traitées au Gramoxone®.

La croissance en hauteur s'est avérée la meilleure dans la zone qui avait été labourée et sillonnée dans son entier et ensuite soumis à des applications de Kerb® et de Princep®. Le fait de passer le motoculteur ou la charrue sur les sillons d'un côté ou des côtés vers le milieu n'a eu aucun effet important sur la croissance, mais plus la bande labourée était large, plus la croissance était bonne.

L'auteur recommande l'établissement de semis de Noyer noir, de Frêne blanc, de Tilleul et d'Érable argenté et de boutures de Peuplier hybride sur l'emplacement d'anciens champs du sud de l'Ontario.

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INTRODUCTION

The elimination or drastic reduction of broadleaf and grass competition is an important prerequisite to the successful establishment and satisfactory early growth of most hardwood species planted on former agricultural land (Lane and McComb 1953, Byrnes 1966, von Althen 1971a). Many mechanical and chemical weed control treatments have been tested but insufficient information is available on the relative effectiveness of individual treatments and treatment combinations. Beginning in 1968 a series of experiments was carried out to compare the effectiveness of various site preparation and weed control treatments on the survival and early growth of five hardwood species commonly planted in southern Ontario (von Althen 1971b, 1974, 1976). This report presents the 5-year results of the final experiment in this series and recommends site preparation and weed control treatments found to be suitable for the successful establishment of black walnut (*Juglans nigra* L.), white ash (*Fraxinus americana* L.), basswood (*Tilia americana* L.), silver maple (*Acer saccharinum* L.) and hybrid poplar plantations.

EXPERIMENTAL AREA

The experiment was carried out in a former field near Hornby, Halton County, Ontario. The soil was an imperfectly drained clay loam 45-61 cm (18-24 in.) deep over compact clay. The pH of the plow layer was 6.8 and the organic matter content was 2.8%. In 1961 the field had been afforested with white pine (*Pinus strobus* L.) and white spruce (*Picea glauca* [Moench] Voss) at a spacing of 3.7 m (12 ft) between rows. By 1974 over 70% of the conifers had died as a result of severe weed competition and stem girdling by meadow voles (*Microtus pennsylvanicus*). The surviving trees were 3 to 4 m tall. Ground cover consisted of a very dense stand of goldenrod (*Solidago* spp.), wild aster (*Aster* spp.), tall buttercup (*Ranunculus acris* L.), wild carrot (*Daucus carota* L.), rough-fruited cinquefoil (*Potentilla erecta* L.) and quackgrass (*Agropyron repens* [L.] Beauv.) (Fig. 1).

METHOD

In the autumn of 1974 the few surviving pine and spruce trees were removed from approximately 1.2 ha (3 ac) of the former plantation. In July of the next year the area was plowed and disked and then disked several times more between July and September. In November 2.2 kg/ha (2 lb/ac) of active pronamide (4.0 lb/ac of Kerb® 50W[1]) were broadcast over the area to eliminate the quackgrass which had survived the plowing and disking (Fig. 2). On an adjacent area 4 ha (10 ac) in size, strips of different width were either plowed and disked (Fig. 3) or rototilled (Fig. 4) between the few surviving trees in the autumn of 1975, or else 1.1 kg/ha (1 lb/ac) of active paraquat (2 qt/ac of Gramoxone®) were sprayed on the herbaceous vegetation in spring shortly before planting (Table 1).

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[1] Reference to commercial products is solely for the information of the reader, and does not constitute endorsement by the Great Lakes Forest Research Centre.

Table 1. Effects of site preparation and post-planting weed control on the survival and height growth of planted basswood, black walnut, white ash, and silver maple seedlings and hybrid poplar cuttings 5 years after planting.

Site preparation	Post-planting weed control with Princep® applied annually in the first 3 years after planting	Basswood		Black walnut		White ash		Silver maple		Hybrid poplar	
		Survival (%)	Height growth (cm)	Survival (%)	Height growth (cm)	Survival (%)	Height growth (cm)	Survival (%)	Height growth (cm)	Survival (%)	Height growth (cm)
Control, no treatment	Continuous band 1.2 m (4 ft) wide.	86*a*	61*lm*	92*a*	52*l*	67*a*	105*lm*	50*a*	24*l*	0*a*	0*l*
Continuous band of Gramoxone® 1.2 m (4 ft) wide shortly before planting.	Continuous band 1.2 m (4 ft) wide.	89*a*	50*l*	92*a*	52*l*	94*b*	71*l*	97*c*	56*lm*	8*a*	79*l*
Three furrows plowed from either side to the middle and disked.	Continuous band 1.2 m (4 ft) wide.	94*a*	63*lm*	97*a*	103*lmn*	94*b*	164*mn*	97*c*	96*lm*	53*b*	210*m*
Six furrows plowed to one side and disked.	Continuous band 1.2 m (4 ft) wide.	94*a*	92*lm*	94*a*	99*lmn*	94*b*	170*mn*	100*c*	93*lm*	92*c*	234*m*
Rototilled strip 1.8 m (6 ft) wide.	Continuous band 1.8 m (6 ft) wide.	89*a*	94*lm*	100*a*	69*lm*	89*b*	163*mn*	100*c*	99*lm*	92*c*	240*m*
Six furrows plowed from either side to the middle and disked.	Continuous band 2.7 m (9 ft) wide.	94*a*	94*lm*	94*a*	130*mn*	100*b*	193*no*	75*b*	100*lm*	66*b*	239*m*
Nine furrows plowed to one side and disked.	Continuous band 2.7 m (9 ft) wide.	92*a*	118*m*	100*a*	124*mn*	78*ab*	182*no*	100*c*	163*m*	87*c*	279*m*
Total area plowed and disked several times; Kerb® broadcast in autumn before planting.	Broadcast over total area.	100*a*	184*n*	97*a*	160*n*	97*b*	250*o*	100*c*	384*n*	94*c*	670*n*

Note: Within species common letters denote treatments without significant differences (p:05) in survival or height growth.

Figure 1

Planting site covered with dense stand of weeds, mainly goldenrod.

Figure 2

Silver maple seedlings at the end of the first growing season in the area plowed and disked in its entirety, and following broadcast applications of Kerb® and Princep® over the total area.

Figure 3. Six furrows plowed from either side to the middle and disked. (Photographed shortly before planting)

Figure 4. Rototilled strip prepared by four passes with the rototiller over the same area. (Photographed shortly before planting)

In April of 1976 2+0 seedlings of white ash, silver maple and basswood, 1+0 seedlings of black walnut or cuttings 30 cm (12 in.) long of the hybrid poplar clone I 45/51 were planted in the area plowed in its entirety and in all strips. All seedlings were obtained from the St. Williams Tree Nursery of the Ontario Ministry of Natural Resources, while the poplar cuttings were obtained from Dr. Zsuffa of the Southern Research Station, Ontario Ministry of Natural Resources. All seedlings were machine planted while the cuttings were hand planted with a dibble. Spacing in the area plowed in its entirety was 3 m (10 ft) between rows and 1.5 m (5 ft) within rows (Fig. 2). In the strips a single row of trees was planted along the centre of the strips at a spacing of 1.5 m between trees.

Shortly after planting, simazine was broadcast over the total plowed and disked area. In the strips simazine was applied in continuous bands of different widths which corresponded with the widths of the site preparation treatments. In the control, simazine was applied in a continuous band 1.2 m (4 ft) wide. In all walnut plots, simazine was applied at a dosage of 6.7 kg/ha (6.0 lb/ac) active ingredient (7.5 lb/ac of Princep® 80W). In the white ash, silver maple, basswood and poplar plots, simazine was applied at a dosage of 3.3 kg/ha (3.0 lb/ac) active ingredient (3.75 lb/ac of Princep® 80W). The same dosages were applied again to all treatments and to the control in April of 1977 and 1978.

The experiment was laid out in a randomized block design with 12 trees per plot of each of the five species. There were three replications for each of the eight treatments for a total of 288 plants per species. Survival was recorded at the end of the first, third and fifth growing seasons and total height was recorded shortly after planting and at the end of the first, third, and fifth growing seasons. Height growth was computed by deducting the height of the seedlings at time of planting from the height recorded at the end of the fifth growing season. The five-year survival data were subjected to chi-square tests of independence and the five-year height growth data were analyzed by analysis of variance and Tukey's test of significance.

RESULTS

Survival of basswood and black walnut was 86% or better under all treatments with no significant differences between treatments (Table 1). White ash survival was significantly lower in the control than in all other treatments except the nine furrows plowed to one side. The survival of silver maple was significantly lower in the control than in all other treatments and was significantly lower in the six furrows plowed from either side to the middle than in all other treatments except the control. All hybrid poplar cuttings died in the control plots and only 8% of the planted cuttings survived in the strips sprayed with Gramoxone® and Princep®. In the strips with three and six furrows plowed from either side to the middle, survival was reduced to

53 and 66%, respectively. These survival rates were significantly lower than those for cuttings planted in strips of six and nine furrows plowed to one side, cuttings in the rototilled strip or cuttings in the area plowed in its entirety.

Height growth of basswood, silver maple (Fig. 5 and 6) and hybrid poplar (Fig. 7 and 8) was significantly higher in the area which had been plowed in its entirety than in all strips or the control (Fig. 9). Height growth of black walnut (Fig. 10 and 11) and white ash (Fig. 12 and 13) was also highest in the area plowed in its entirety but the growth differences were not significant between this area and several of the strips. The height growth of hybrid poplar was significantly lower in the strip treated with Gramoxone® and Princep® than in all other plots except the control, where there were no survivors.

DISCUSSION

Weed control is essential to the successful afforestation of former agricultural land with hardwood trees. Since all hardwood species of high timber value grow adequately only in deep, fertile soils, they must be planted on sites which also support dense stands of weeds and grasses. In contrast, sites with only sparse vegetation, which require little or no weed control, are most unlikely to be suitable for hardwood timber species.

Although many mechanical and chemical site preparation and post-planting weed control treatments are available, information is still lacking on their relative effectiveness, singly and in combination. A series of four experiments was therefore begun in 1968 to compare the effectiveness of the most promising treatment combinations.

The results of the first experiment showed that white ash and black walnut seedlings planted on land that had been plowed and disked in its entirety and had received broadcast applications of Princep® over the total area had significantly greater height growth than seedlings which had been planted in the bottom of plowed furrows with Princep® applied to the bottom of the furrows (von Althen 1971b).

The results of the second experiment showed that the height growth of black walnut seedlings was significantly greater in plowed strips of different width, sprayed with Princep® at corresponding widths, than in unplowed strips which were sprayed with Princep® (von Althen 1976).

In the third experiment black walnut, basswood, white ash and cottonwood (*Populus* spp.) seedlings were planted in either plowed or rototilled strips of different widths with Princep® sprayed at corresponding widths, or on individual planting spots sprayed with Gramoxone® and Princep®. With few exceptions height growth of black

Figure 5

Silver maple seedlings five years after planting in the rototilled strip and following band applications of 4.1 kg/ha (3.75 lb/ac) of Princep® 80W in each of the first three years after planting.

Figure 6

Silver maple seedlings five years after planting in the area plowed and disked in its entirety and following broadcast applications of 4.1 kg/ha (3.75 lb/ac) of Princep® 80W over the total area in each of the first three years after planting.

Figure 7

Hybrid poplar cuttings five years after planting in a rototilled strip and following band applications of 4.1 kg/ha (3.75 lb/ac) of Princep® 80W in each of the first three years after planting.

Figure 8

Hybrid poplar cuttings five years after planting in the area plowed and disked in its entirety and following broadcast applications of 4.1 kg/ha (3.75 lb/ac) of Princep® 80W over the total area in each of the first three years after planting.

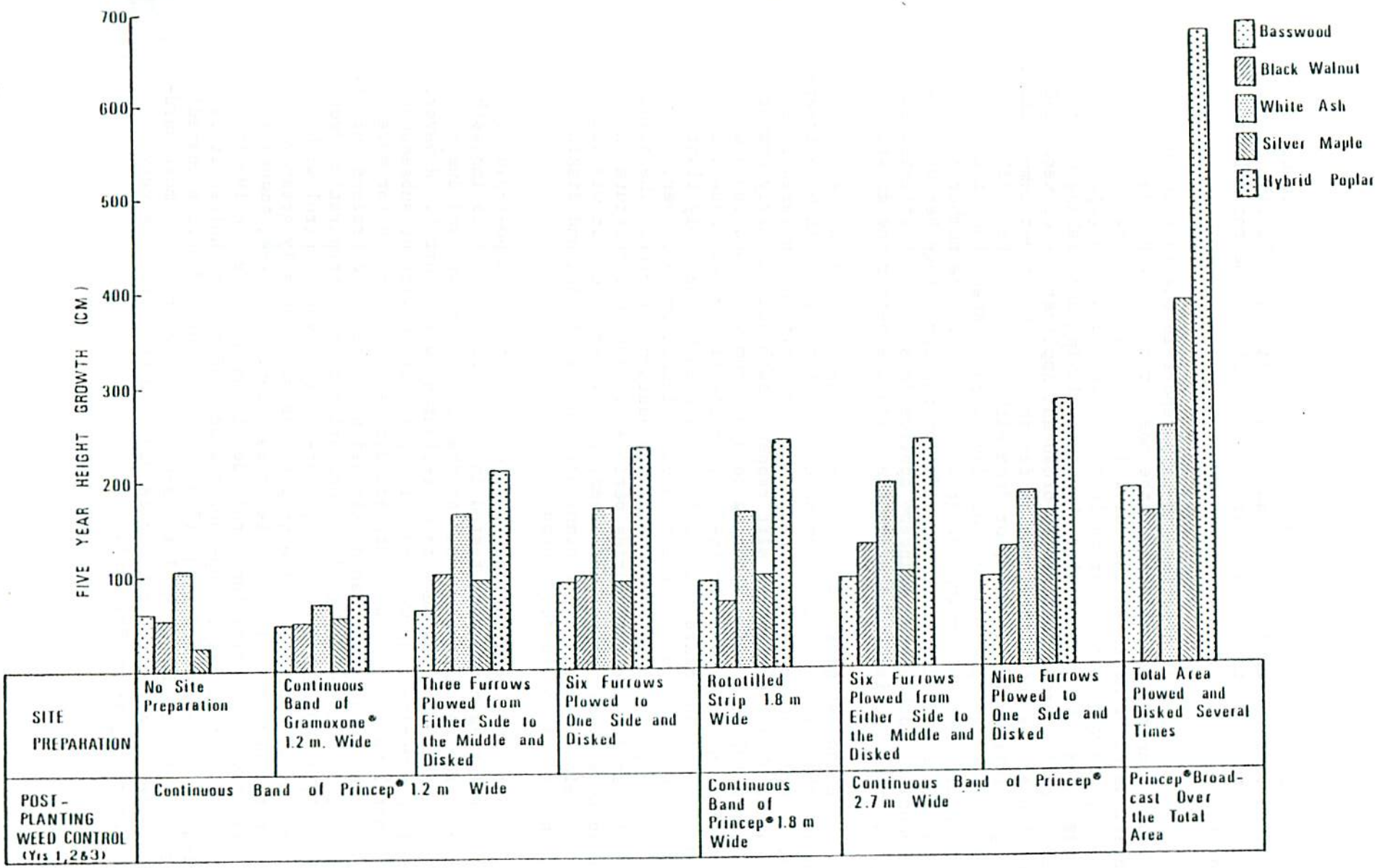

Figure 9. Five-year height growth of basswood, black walnut, white ash and silver maple seedlings and hybrid poplar cuttings by site preparation and post-planting weed control treatments.

walnut, basswood and white ash seedlings was significantly higher in the plowed or rototilled strips than on the individual planting spots. Height growth of cottonwood was very poor in all but the rototilled strips (von Althen 1976).

The experiment described in this report is the last of this series and compares the effects of the most promising treatments of the previous experiments on the survival and growth of black walnut, white ash, basswood and silver maple seedlings and hybrid poplar cuttings. The five-year results show that plowing and disking of the total plantation area, followed by broadcast applications of Kerb® and Princep® over the total area, was by far the best treatment combination. Plowing of furrows to one side, or from either side to the middle to form a broad ridge on which the seedlings were planted, had little effect on either tree survival or growth. However, the number of furrows plowed, and therefore the width of the strip together with the corresponding width of the Princep® applications, greatly affected the growth of most species. The wider the strip the better the growth.

The poorest growth for all species was recorded in the control plots and those sprayed with Gramoxone®. Most seedlings in both treatments, in addition to facing intense weed competition, suffered severe root damage when the planting slit reopened each year in early summer (von Althen 1977a). This reopening to a maximum width and depth of 5.5 cm (2.2 in.) and 15-20 cm (6-8 in.), respectively, was caused by soil drying and shrinkage (Fig. 14). As a result, the newly planted seedlings and cuttings lost their support, leaned or fell over, exposing roots to drying, and to the depredations of mice. The planting split partially closed during periods of high soil moisture and reopened to a lesser extent each summer. However, the slit was still clearly visible 5 years after planting. In the plowing and disking treatments the slit did not reopen (Fig. 15).

Since only combinations of site preparation and post-planting weed control treatments were tested in this experiment it is impossible to assess with certainty how much of the improved growth was due to site preparation and how much to post-planting weed control. However, a previous experiment showed that site preparation without subsequent weed control was unable to assure adequate seedling growth for more than one year because the rapid reinvasion of weeds and grasses quickly restored the intense competition found prior to site preparation (von Althen 1977b). On the other hand, post-planting weed control with Princep® but without prior site preparation was generally greatly inferior to weed control plus site preparation. Princep®, though a very effective pregermination herbicide, is much less effective in killing well established, deep-rooted weeds and grasses unless it is applied at dosages of 8.2 kg/ha (7.5 lb/ac) or more of active ingredient --dosages which injure or kill the seedlings or cuttings of most hardwood species. The only exception is black walnut, which is very resistant to injury by Princep®.

Figure 10

Black walnut seedlings five years after planting in a strip without site preparation but following band applications of 6.7 kg/ha (7.5 lb/ac) of Princep® 80W in each of the first three years after planting.

Figure 11

Black walnut seedlings five years after planting in the area plowed and disked in its entirety and following broadcast applications of 6.7 kg/ha (7.5 lb/ac) of Princep® 80W in each of the first three years after planting.

Figure 12

White ash seedlings five years after planting in a rototilled strip and following band applications of 4.1 kg/ha (3.75 lb/ac) of Princep® 80W in each of the first three years after planting.

Figure 13

White ash seedlings five years after planting in the area plowed and disked in its entirety and following broadcast applications of 4.1 kg/ha (3.75 lb/ac) of Princep® 80W in each of the first three years after planting.

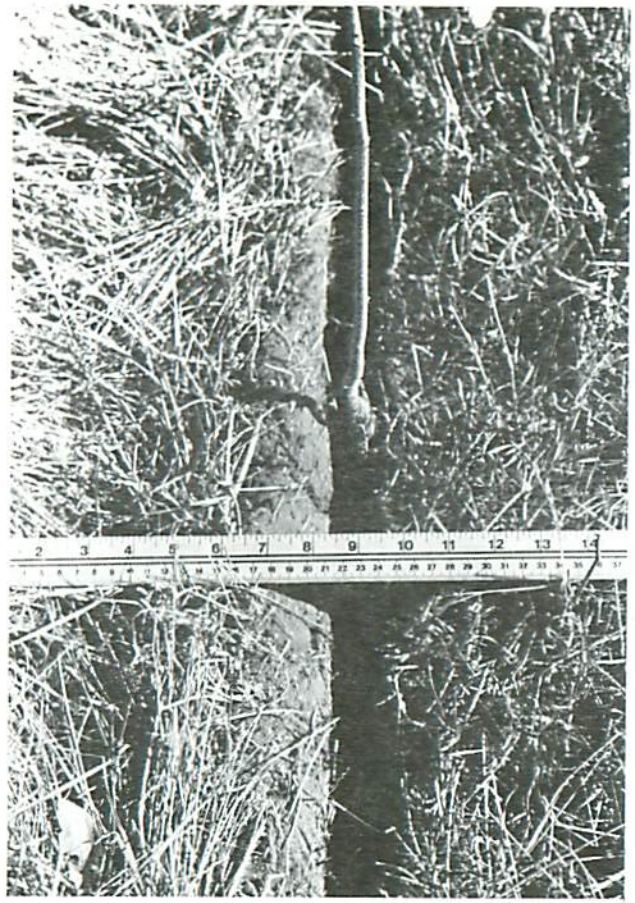

Figure 14. Reopened planting slit in a clay loam soil which received no mechanical site preparation. (Photographed in July following spring planting)

Figure 15. Tightly closed planting slit following plowing and disking of the same clay loam soil shown in Figure 14. (Photographed in July following spring planting)

Gramoxone® proved to be of little value in controlling the herbaceous vegetation because it killed only the above-ground parts of the vegetation and most weeds and grasses quickly regrew from the healthy roots. A better herbicide for site preparation is the recently developed Roundup® (Sutton 1978, von Althen 1979a). Roundup® is a non-selective contact herbicide which kills or injures almost all plants, including tree seedlings, when sprayed on the foliage. Roundup® is therefore most safely used before the tree seedlings are planted. When entering the soil, Roundup® is quickly inactivated so that planting may be done within days of application.

The decision of whether to use mechanical or chemical site preparation depends mainly on the soil of the plantation site, the wishes of the owner, and the availability of manpower and equipment. Agricultural research has shown that, in certain soils, herbicides may be used as alternatives to plowing without significant reductions in yields of certain crops (Arnott and Clement 1966). However, the effects of such practices on soil moisture, soil physical conditions, nitrate, and organic content are not yet fully known (Dowdell and Cannell 1975). In forestry, plowing and disking have been recommended for the establishment of walnuts (Byrnes et al. 1975, 1978), cottonwoods (McKnight and Biesterfeldt 1968, Jaciw 1977) and white birch (*Betula papyrifera* Marsh.) (Bjorkbom 1972). The results of the experiment described in this report show that plowing and disking of the total plantation area followed by broadcast applications of Kerb® and Princep® produced higher growth than the plowing of strips which, in turn, produced higher growth than site preparation with Gramoxone® or no site preparation. However, plowing and disking of the total plantation area, or even of strips, may not be feasible or desirable on planting sites which are inaccessible to farm equipment, are partially treed, or are subject to erosion. On these sites herbicides are the logical alternatives to mechanical site preparation.

RECOMMENDATIONS

On the basis of the results of this study and previous studies (von Althen 1971a,b, 1974, 1976, 1977), the following recommendations are made for the afforestation of old fields in southern Ontario with black walnut, white ash, basswood, silver maple, and hybrid poplar.

A. Site preparation.

1. Plow and disk the total plantation area in summer and disk several times more in autumn prior to spring planting. In areas with heavy quackgrass infestations, broadcast 2.2 kg/ha (2 lb/ac) of active pronamide (4.0 lb/ac of Kerb® 50W) over the infested area in late October or early November.

2. On sites where plowing and disking of the total plantation area are not feasible, either rototill, plow and disk or, in summer of the year prior to spring planting, spray Roundup® in strips at least 2.7 m wide (9 ft) (wider if possible). For Roundup® spraying mix 30 ml (1 fl oz) of Roundup® with each 4.5 L (1 gal) of water and wet the foliage uniformly and completely, but avoid runoff from the leaf surface.

3. On sites where mechanical or chemical weed control in strips is not feasible, spray Roundup® in circular spots at least 1.2 m (4 ft) in diameter in summer before the next spring planting. Mix 30 ml (1 fl oz) of Roundup® with each 4.5 L (1 gal) of water and wet the foliage uniformly and completely, but avoid runoff from the leaf surface.

B. Post-planting weed control.

1. In areas where the total planting site was plowed and disked, broadcast Princep® Nine-T over the total area in the spring shortly after planting and in April of the second and third years after planting. For black walnut mix 6.6 kg/ha (6 lb/ac) of Princep® Nine-T and for all other hardwood species 4.4 kg/ha (4 lb/ac) in 200 L (45 gal) of water.

2. On plowed and disked strips apply Princep® Nine-T over the total width of the strips. Use the same dosage per ha sprayed as shown for the plowed and disked area.

3. On site-prepared spots apply Princep® Nine-T over each spot. For the preparation of the proper mixture and the calibration of the sprayer, consult the Appendix.

4. For post-planting weed control with Princep® Nine-T in black walnut plantations which have received no site preparation apply 8.0 kg/ha (7.5 lb/ac) of active ingredient (8.0 kg/ac of Princep® Nine-T). Do *not* apply this treatment to any other hardwood species because the seedlings will be seriously injured or killed by the recommended dosage while smaller dosages will be ineffective in providing adequate weed control.

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APPENDIX

APPENDIX

Calculation of Herbicide Dosage for the Spraying of Individual Planting Spots

Application of the correct dosage of herbicide on individual planting spots is difficult to obtain because it is influenced by each of the following factors: (1) concentration of the herbicide in the spray mixture, (2) pressure within the spray tank, (3) size of the sprayed spot, (4) spray time per spot, and (5) number of spots sprayed. A change in any one of these factors will alter the dosage applied.

Because the size of spray tanks, the types of nozzles and tank pressures vary widely, and no two persons consistently treat the same number of spots of equal size with the same amount of solution, each person planning to spray must find his or her own rate of application with the equipment available.

This is done by first deciding what size of spot should be treated. Then a spot of this size is marked on the ground (circle of 4 ft (1.22 m) or any other diameter). The spray tank is filled with clean water and tank pressure is obtained by pumping. While some tanks maintain pressure through slow continuous pumping, pressure in other tanks is maintained by pumping at frequent intervals. The total amount of water in the tank is then sprayed over the marked spot in the same manner as one would spray different spots in the field. The number of times the marked spot is sprayed with each tankful of water is counted and recorded. This procedure is repeated five times to establish the average number of spots treated with one tank of water. This routine does not only determine the average number of spots treated per tank, but also trains the person who will do the spraying to spray consistently plots of the same size and for the same length of time.

The next step is the determination of the amount of herbicide needed for mixing in each tank of water. This amount depends on the recommended dosage of herbicide per acre or hectare and the size of the area covered with one tank of mixture. For example, for a recommended dosage of 5.0 lb/ac (5.5 kg/ha) of Princep® Nine-T, if one tank of mixture treats 100 circular spots, each with a diameter of 4 ft (1.22 m), the area treated with one tank is $\pi r^2 \times 100$ where $\pi = 3.14$ and r = the radius of the circle. Therefore $3.14 \times 2^2 \times 100 = 1256$ sq. ft (117 sq. m). $\frac{1256}{43560} = 0.0288$ ac (0.0117 ha) = 2.3 oz/ac (65 g/ha) = 6 tbsp or 35 mL/ac.

The above calculations have been carried out for Princep® Nine-T in Table A-1 and for Roundup® in Table A-2 for a range of recommended dosages, spot sizes and number of spots treated per tank of mixture.

To find the correct amount of Princep® Nine-T or Roundup® for mixing with one tank of water use Tables A-1 and A-2 as follows:

(1) In columns 1 or 2 find the recommended dosage per acre or hectare you wish to apply in your plantation.

(2) In columns 3 or 4 find the spot size you wish to use.

(3) In column 5 find the number of spots closest to that which you have established in your own tests.

(4) In columns 6 or 7 find the number of tablespoons* or millilitres which must be mixed with water to obtain the correct dosage.

*Use only plastic or metal measuring spoons or a measuring cup graduated in millilitres. Do *not* use ordinary tablespoons.

Table A-1. Application rates for spraying Princep® Nine-T on individual spots.

Recommended dosage of Princep®		Diam of treated spot		Spots treated	Required Princep®		Recommended dosage of Princep®		Diam of treated spot		Spots treated	Required Princep®	
lb/ac	kg/ha	in.	cm		heaped[a] tbsp	mL[b]	lb/ac	kg/ha	in.	cm		heaped[a] tbsp	mL[b]
3	3.3	36	91	50	1.0	10	5	5.5	36	91	50	2.0	10
				100	2.0	15					100	3.5	20
				150	3.0	20					150	5.0	30
				200	4.0	25					200	6.5	40
				250	5.0	30					250	8.0	50
		48	122	50	2.0	10			48	122	50	3.0	15
				75	3.0	15					75	4.5	25
				100	4.0	20					100	6.0	35
				125	4.5	25					125	7.5	45
				150	5.5	30					150	9.0	55
		60	152	25	1.5	8			60	152	25	2.0	15
				50	3.0	15					50	4.5	30
				75	4.0	25					75	7.0	45
				100	5.5	35					100	9.5	60
				125	7.0	45					125	12.0	75
4	4.4	36	91	50	1.5	8	6	6.6	36	91	50	2.0	10
				100	2.5	15					100	4.0	25
				150	4.0	25					150	6.0	35
				200	5.5	35					200	8.0	50
				250	6.5	45					250	10.0	60
		48	122	50	2.5	15			48	122	50	3.5	25
				75	3.5	20					75	5.5	35
				100	5.0	30					100	7.0	45
				125	6.0	35					125	9.0	55
				150	7.0	45					150	10.5	65
		60	152	25	2.0	15			60	152	25	3.0	15
				50	3.5	25					50	5.5	35
				75	5.5	35					75	8.5	50
				100	7.5	45					100	11.0	70
				125	9.5	55					125	14.0	85

[a] Use measuring spoon, not ordinary tablespoon.

[b] Use measuring cup graduated in millilitres.

Table A-2. Application rates for spraying Roundup® on individual spots.

Recommended dosage of Roundup®		Diam of treated spot		Spots treated	Level tbsp[a] Roundup®	Required Roundup®
qt/ac	L/ha	in.	cm			mL
1	1.1	36	91	50	.5	9
				100	1.5	27
				150	2.0	36
				200	3.0	53
				250	3.5	62
		48	122	50	1.0	18
				75	2.0	36
				100	2.5	44
				125	3.0	53
				150	3.5	62
		60	152	25	1.0	18
				50	2.0	36
				75	3.0	53
				100	4.0	71
				125	5.0	89
2	2.3	36	91	50	1.5	27
				100	2.5	44
				150	4.0	71
				200	5.5	98
				250	7.0	124
		48	122	50	2.5	44
				75	3.5	62
				100	5.0	89
				125	6.0	107
				150	7.5	133
		60	152	25	2.0	36
				50	4.0	71
				75	6.0	107
				100	8.0	142
				125	10.0	178
3	3.4	36	91	50	1.5	27
				100	4.5	80
				150	6.0	107
				200	9.0	160
				250	10.5	186
		48	122	50	3.0	53
				75	4.5	79
				100	6.0	107
				125	7.5	133
				150	9.0	160
		60	152	25	3.0	53
				50	6.0	107
				75	9.0	160
				100	12.0	213
				125	15.0	267

[a]Use measuring spoons, not ordinary tablespoons.