EFFECTS OF SITE PREPARATION AND POST-PLANTING WEED CONTROL ON THE SURVIVAL AND HEIGHT GROWTH OF PLANTED HARDWOOD SEEDLINGS

F. W. VON ALTHEN

GREAT LAKES FOREST RESEARCH CENTRE

SAULT STE. MARIE, ONTARIO

REPORT O-X-248

CANADIAN FORESTRY SERVICE

DEPARTMENT OF THE ENVIRONMENT

MAY 1976

Copies of this report may be obtained from

Information Office,
Great Lakes Forest Research Centre,
Department of the Environment,
Box 490, Sault Ste. Marie, Ontario.
P6A 5M7

Frontispiece. Second-year height growth of black walnut seedlings planted in a rototilled strip.

ABSTRACT

Three studies were carried out near Hornby, Ontario to determine the effects of plowing and herbicide spraying in strips and herbicide spraying on individual planting spots on the survival and height growth of planted hardwood seedlings. In the first experiment plowing of strips of different widths had no significant effect on the survival of black walnut (*Juglans nigra* L.) seedlings 5 years after planting, but 5-year height growth was significantly better than that of the control in three out of four treatments. In the second experiment planting on plowed and disked strips failed to increase significantly the 4-year survival of black walnut, sugar maple (*Acer saccharum* Marsh.), and cottonwood (*Populus deltoides* Bartr.) seedlings and the 4-year height growth of sugar maple and white ash (*Fraxinus americana* L.) seedlings. However, height growth of black walnut was significantly better than that of the control in strips with nine furrows plowed to one side or six furrows plowed from either side to the middle. Cottonwood height growth was significantly better than that of the control in a strip with twelve furrows plowed to one side. In the third study 3-year height growth of black walnut, basswood (*Tilia americana* L.), and white ash seedlings was significantly better in the sprayed, plowed or rototilled strips than on the individual planting spots, while the 3-year survival and height growth of cottonwood seedlings was very poor in all treatments except in the rototilled strip. Recommendations are made for the successful establishment of black walnut, white ash, basswood, and cottonwood seedlings on old field sites in southern Ontario.

RÉSUMÉ

L'auteur effectua trois études près de Hornby, Ontario, afin de trouver les effets du labourage et de la pulvérisation d'herbicide par bandes, et de la pulvérisation d'herbicide par points, ce sur la survie et la croissance en hauteur de plants de feuillus. Lors de la première expérience, le labourage par bandes de différentes largeurs n'influa pas significativement sur la survie de plants de Noyer noir (*Juglans nigra* L.) 5 ans après plantation mais leur croissance se révéla significativement meilleure que celle des témoins dans 3 sur 4 cas. Lors de la deuxième expérience, le plantage dans des bandes labourées et hersées ne put augmenter significativement le taux de survie (durant 4 ans) des plants de Noyer noir, Erable à sucre (*Acer saccharum* Marsh.) et Peuplier liard (*Populus deltoides* Bartr.) et la croissance (en hauteur) de 4 ans des plants de l'Erable à sucre et du Frêne blanc (*Fraxinus americana* L.). La croissance en hauteur de Noyer noir fut cependant meilleure significativement que celle des témoins dans des bandes avec 9 sillons labourés vers un côté ou 6 sillons labourés d'un côté et l'autre vers le milieu. La croissance en hauteur du Peuplier liard fut significativement meilleure que celle des témoins dans une bande à douze sillons labourés vers un côté. Lors de la troisième expérience, la croissance en hauteur du Noyer noir, du Tilleul américain (*Tilia americana* L.) et du Frêne blanc se montra significativement supérieure dans les bandes arrosées d'herbicide, labourées ou hersées que dans les points individuels de plantage, tandis que la survie durant 3 ans et la croissance en hauteur des Peupliers liards se montrèrent très pauvres en tous cas, sauf dans les bandes hersées. L'auteur donne des conseils sur l'établissement des plants de Noyer noir, de Frêne blanc, de Tilleul américain et de Peuplier liard dans les champs abandonnés sis dans le sud de l'Ontario.

TABLE OF CONTENTS

INTRODUCTION

Weed control is one of the most important prerequisites to successful hardwood plantation establishment as demonstrated by the many hardwood plantation failures which have been traced directly to inadequate weed control during the early life of the plantations (Brynes 1966, Figzgerald et al. 1973). Since most hardwood species require, for best growth, a moist but well-drained fertile soil, weed growth is always very luxuriant on all good hardwood planting sites. Previous studies have shown that established weeds may be eliminated successfully by plowing and disking of the total plantation area (von Althen 1971). However, this method is not always feasible or desirable as, for example, on sloping ground, where the soil is subject to erosion, or in partially treed areas.

To find a suitable alternative to plowing and disking of the total plantation area, a series of experiments was carried out in which the growth response of different hardwood species to various mechanical and chemical site-preparation and weed-control treatments was compared. The results of these experiments are reported here.

EXPERIMENTAL AREA

All experiments were carried out in a former field near Hornby, Halton County, Ontario. The soil was an imperfectly drained clay loam 18-24 in. (45-61 cm) deep over compact clay. The pH of the plow layer was 6.8 and the organic matter content was 2.8%. In 1960-1961 the field had been afforested with white pine (*Pinus strobus* L.) and white spruce (*Picea glauca* [Moench] Voss) at a spacing of 12 ft (3.7 m) between rows. By 1971 over 60% of the conifers had died as the result of severe weed competition and stem girdling by voles. The surviving trees were 6-8 ft (1.8-2.4 m) tall. Ground cover consisted of a very vigorous stand of quackgrass (*Agropyron repens* [L.] Beauv.), timothy (*Phleum pratense* L.), goldenrod (*Solidago* spp.), wild carrot (*Daucus carota* L.), tall buttercup (*Ranunculus acris* L.), rough-fruited cinquefoil (*Potentilla erecta* L.), Canada thistle (*Cirsium arvense* [L.] Scop), and wild aster (*Aster* spp.) (Fig. 1).

METHOD

In all experiments reported here a tractor-drawn three-furrow plow was used. The widths of the plowed strips were therefore always in multiples of three furrows. All trees in all studies were spade-planted in May using the wedge method or, where it was too time-consuming or too exhausting to cut a wedge, the slit method. Gramoxone®[1]

---

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

Fig. 1. Planting site with heavy weed cover.

and Princep ® were broadcast over the strips using a motorized backpack mist blower (Fig. 2). A pressurized hand sprayer was used to apply the herbicides over the individual planting spots (Fig. 3).

Study 1

At the beginning of May, 1971 strips of different widths were plowed between the rows of conifers (Table 1). The average depth of the furrows was 7 in. (18 cm). Shortly after plowing, black walnut (1+0) seedlings were planted by spade in single rows along the center of the plowed strips at a spacing of 5 ft (1.5 m). Within two days of planting, 6 lb/acre (6.7 kg/ha) of active Princep ® were broadcast over the strips in continuous bands of different width. The same applications were repeated in April of the following year.

The study was laid out in a randomized block arrangement with 12 trees in each of five treatments. Each treatment was replicated four times for a total of 240 trees. Seedling survival and height growth were recorded after the first, third and fifth years with the fifth-year data subjected to an analysis of variance and Duncan's New Multiple Range Test (Steel and Torrie 1960).

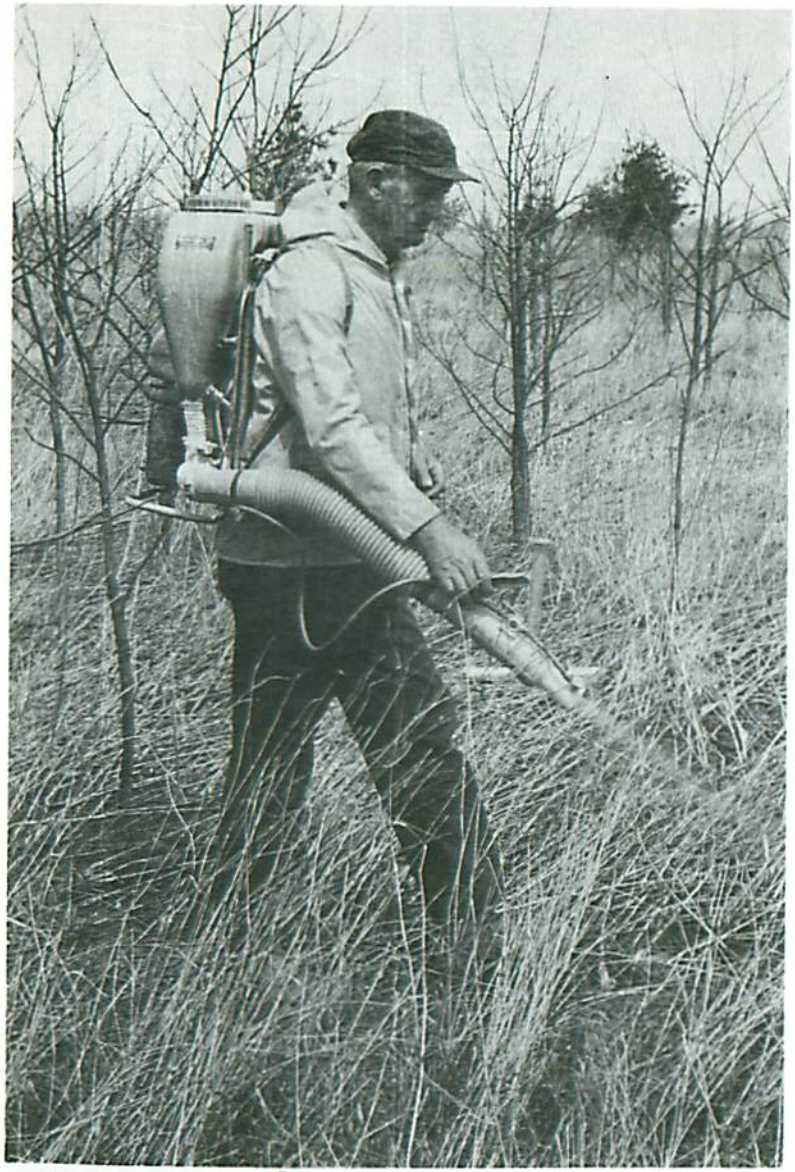

Fig. 2. Princep® application using a motorized backpack mist blower.

Fig. 3. Spot treatment using a pressurized hand sprayer.

Table 1. Effects of site preparation and weed control on survival and height growth of black walnut seedlings 5 years after planting

Treatment number	Site preparation	Post-planting weed control with Princep®	Survival (%)	Height growth (in.)[a]
1	No treatment	continuous band 6 ft[b] wide	96	55 y
2	Three furrows plowed from either side to the middle	continuous band 6 ft wide	81	79 x
3	Six furrows plowed from either side to the middle	continuous band 9 ft wide	98	73 x
4	Six furrows plowed to one side	continuous band 6 ft wide	88	51 y
5	Twelve furrows plowed to one side	continuous band 4 ft wide	77	79 x

[a] 1 in. = 2.54 cm

[b] 1 ft = 30.48 cm

NOTE: Common letters denote treatments which showed no significant difference (P .05) in survival or height growth.

Study 2

In September, 1971 strips of different widths were plowed and disked between the rows of conifers (Table 2). The average depth of the furrows was 7 in. (18 cm). In April, 1972 black walnut (1+0), sugar maple (2+0), white ash (2+0) and cottonwood (2+0) seedlings were planted by spade in single rows along the center of the plowed and disked strips at a spacing of 6 ft (1.8 m). Shortly after planting and in April of the following year Princep® was broadcast over the strips in continuous bands at the following dosages of active ingredient in the first and second year, respectively: black walnut 8 lb/acre (9.0 kg/ha) and 4 lb/acre (4.5 kg/ha), white ash and cottonwood 3 lb/acre (3.4 kg/ha) and 3 lb/acre (3.4 kg/ha), sugar maple 2 lb/acre (2.2 kg/ha) and 2 lb/acre (2.2 kg/ha).

The study was laid out in a randomized block arrangement with 10 trees per species in each of the seven treatments. Each treatment was replicated three times for a total of 210 trees per species. Seedling survival and height growth were recorded after the first, third and fourth years with the fourth-year data subjected to an analysis of variance and Duncan's New Multiple Range Test.

Table 2. Effects of site preparation and weed control on the survival and height growth of planted black walnut, sugar maple, white ash and cottonwood seedlings 4 years after planting

Treatment number	Site preparation	Post-planting weed control with Princep®	Black walnut		Sugar maple		White ash		Cottonwood	
			Survival (%)	Height growth (in.)[a]	Survival (%)	Height growth (in.)	Survival (%)	Height growth (in.)	Survival (%)	Height growth (in.)
1	Control, no treatment	continuous band 4 ft[b] wide	100	20 z	97	22	97 x	23	57	73 yz
2	Three furrows plowed to one side	continuous band 4 ft wide	93	24 yz	93	27	76 x	23	43	44 z
3	Six furrows plowed to one side	continuous band 6 ft wide	97	30 y	100	30	50 y	20	87	98 xy
4	Nine furrows plowed to one side	continuous band 9 ft wide	90	44 x	97	29	97 x	48	87	84 xyz
5	Twelve furrows plowed to one side	continuous band 12 ft wide	97	27 yz	97	20	57 y	14	83	113 x
6	Three furrows plowed from either side to the middle	continuous band 4 ft wide	100	28 yz	90	28	97 x	34	87	62 yz
7	Six furrows plowed from either side to the middle	continuous band 9 ft wide	100	47 x	97	31	90 x	26	77	89 xyz

[a] 1 in. = 2.54 cm

[b] 1 ft = 30.48 cm

NOTE: Common letters denote treatments which showed no significant differences (P .05) in survival or height growth.

Study 3

Strips of different widths were plowed in either October, 1972 or April, 1973 (Table 3). In April, 1973 a continuous strip 4 ft (1.2 m) wide, as well as individual planting spots 2 ft (0.6 m) and 4 ft (1.2 m) in diameter, were sprayed with 2 qt per acre (5.6 liters/ha) of Gramoxone®. When spring plowing and Gramoxone® spraying were completed, black walnut (1+0), basswood (2+0), white ash (2+0), and cottonwood (2+0) seedlings were planted by spade either in single rows along the center of the strips or as single trees in the center of individual planting spots. All trees were spaced 5 ft (1.5 m) within the rows.

Shortly after planting and in April of each of the next two years Princep® was broadcast over the strips in continuous bands or was applied as spot treatments on individual planting spots in the following dosages of active ingredient: black walnut 8 lb/acre (9.0 kg/ha), basswood, white ash and cottonwood 3 lb/acre (3.4 kg/ha).

The study was laid out in a randomized block arrangement with 10 trees per species in each of 20 treatments. Each treatment was replicated three times for a total of 600 trees per species. Girdling and browsing damage were recorded after the first and third years. Seedling survival and height growth were recorded after the first and third years with the third year data subjected to an analysis of variance and Duncan's New Multiple Range Test.

RESULTS

Since the studies were carried out in three consecutive years with planting stock grown from different seed lots in different years, the results of the three studies are not statistically comparable. Some of the variations in results between similar treatments were probably due also to differences in the quality of planting stock or weather conditions in the year of planting.

Study 1

Site preparation and weed control had no significant effect on the 5-year survival of black walnut but height growth was significantly better than that of the control in three out of four treatments (Table 1).

Study 2

Site preparation and weed control had no significant effects on the survival of black walnut, sugar maple and cottonwood seedlings or the height growth of sugar maple and white ash seedlings (Table 2).

Table 3. Effects of site preparation and weed control on the survival and height growth of black walnut, basswood, white ash, and cottonwood seedlings 3 years after planting

Treatment number	Site preparation	Post-planting weed control with Princep®	Black walnut		Basswood		White ash		Cottonwood	
			Survival (%)	Height growth (in.)[a]	Survival (%)	Height growth (in.)	Survival (%)	Height growth (in.)	Survival (%)	Height growth (in.)
1	Control, no treatment	Control, no treatment	40 g	0 w	85 ab	5 wx	67 abcde	1 z	8 fgh	0 x
2	No treatment	Individual spot 2 ft[b] in diameter	40 g	0 w	77 abc	8 wx	42 efgh	3 z	0 h	0 x
3	No treatment	Individual spot 4 ft in diameter	42 fg	3 w	77 abc	6 wx	25 h	12 yz	8 fgh	0 x
4	No treatment	Continuous strip 4 ft in diameter .	87 abc	16 v	100 a	23 uv	72 abcd	16 wxy	32 de	5 x
5	Individual spot 2 ft in diameter sprayed with 2 qt/acre Gramoxone® before planting	No treatment	27 g	0 w	85 ab	6 wx	57 bcdefgh	2 z	3 h	0 x
6	Individual spot 2 ft in diameter sprayed with 2 qt/acre Gramoxone® before planting	Individual spot 2 ft in diameter	32 g	0 w	85 ab	7 wx	40 efgh	2 z	0 h	0 x
7	Individual spot 2 ft in diameter sprayed with 2 qt/acre Gramoxone® before planting	Individual spot 4 ft in diameter	63 cdefg	5 w	70 bcde	7 wx	50 cdefg	0 z	0 h	0 x
8	Individual spot 4 ft in diameter sprayed with 2 qt/acre Gramoxone® before planting	No treatment	35 g	0 w	72 abcd	6 wx	65 abcdef	2 z	30 def	0 x
9	Individual spot 4 ft in diameter sprayed with 2 qt/acre Gramoxone® before planting	Individual spot 2 ft in diameter	35 g	0 w	47 e	1 x	45 defgh	4 z	8 fgh	1 x
10	Individual spot 4 ft in diameter sprayed with 2 qt/acre Gramoxone® before planting	Individual spot 4 ft in diameter	72 abcde	2 w	20 f	7 wx	37 fgh	3 z	10 efgh	6 x
11	Continuous strip 4 ft wide sprayed with 2 qt/acre Gramoxone® before planting	Continuous strip 4 ft wide	92 ab	18 v	90 ab	14 vw	85 ab	26 uvw	70 b	19 vw
12	Three furrows plowed from either side to the middle in autumn previous to spring planting	Continuous strip 4 ft wide	77 abcde	17 v	85 ab	22 uv	77 abc	18 vwxy	32 d	19 vw
13	Six furrows plowed from either side to the middle in autumn previous to spring planting	Continuous strip 6 ft wide	87 abc	27 u	97 ab	22 uv	65 abcdef	25 uvw	37 ed	8 x
14	Three furrows plowed to one side in autumn previous to spring planting	Continuous strip 4 ft wide	82 abcd	6 w	52 cde	18 uv	85 ab	13 xy	47 ed	8 x
15	Six furrows plowed to one side in autumn previous to spring planting	Continuous strip 6 ft wide	92 ab	22 uv	100 a	36 u	75 abc	15 xy	57 bc	27 vw
16	Three furrows plowed from either side to the middle in spring shortly before planting	Continuous strip 4 ft wide	85 abcd	19 v	82 ab	30 uv	35 gh	29 uv	2 gh	13 wx
17	Six furrows plowed from either side to the middle in spring shortly before planting	Continuous strip 6 ft wide	57 defg	24 uv	45 e	14 v	67 abcde	27 uv	25 def	20 vw
18	Three furrows plowed to one side in spring shortly before planting	Continuous strip 4 ft wide	70 bcdef	8 w	82 ab	24 uv	75 abc	33 u	7 fgh	11 wx
19	Six furrows plowed to one side in spring shortly before planting	Continuous strip 6 ft wide	52 efg	17 v	47 de	24 uv	65 abcdef	33 u	12 efgh	27 vw
20	6-ft-wide strip rototilled in spring shortly before planting	Continuous strip 6 ft wide	100 a	18 v	85 ab	17 vw	92 a	28 uv	100 a	56 u

[a] 1 in. = 2.54 cm.

[b] 1 ft = 30.48 cm.

NOTE: Common letters denote treatments which showed no significant difference (P .05) in survival or height growth.

The survival of white ash seedlings was significantly lower in treatments three and five than in all other treatments. Height growth of black walnut seedlings was significantly better than that of the controls in treatments four and seven while height growth of cottonwood seedlings was significantly better than that of the control in treatments three, four, five and seven.

Study 3

Site preparation and weed control significantly affected the 3-year survival and height growth of all four species (Table 3). Although survival varied widely between treatments, black walnut, white ash and cottonwood survival were generally higher in the sprayed, plowed or rototilled strips than on the individual planting spots. Average survival of basswood was higher than that of all other species but no group of treatments showed a significantly better survival than any other group.

With few exceptions height growth of black walnut, basswood, and white ash were significantly better in the sprayed, plowed or rototilled strips than on the individual planting spots. Height growth of cottonwood was very poor in all but the rototilled strip.

DISCUSSION

The effectiveness of weed control during the first few years after planting depends largely on the intensity of site preparation with the most intensively prepared sites requiring the least weed control (von Althen 1972). If Princep ® is used, site preparation is especially important for the successful establishment of those hardwood species that are highly susceptible to Princep ® damage at dosages necessary for the effective control of deep-rooted perennial weeds. For example, to control effectively goldenrod, wild aster, and other deep-rooted perennial weeds, application of 4-8 pounds per acre (4.5-9.0 kg/ha) of active Princep ® are required. However, cottonwood and white ash seedlings may be damaged by applications of more than 3 pounds of active Princep ® per acre (3.4 kg/ha). If, therefore, the deep-rooted perennial weeds are not eliminated *before* the trees are planted it is most difficult, if not impossible, to control weed growth after planting. However, once the perennial weeds have been eliminated by site preparation, an annual application of 3 pounds per acre (3.4 kg/ha) of active Princep ® will generally prevent reestablishment or at least keep weed competition to an acceptable level.

The best method of site preparation developed to date is the plowing and disking of the total plantation area because this method offers advantages not obtainable by any other method: it destroys all weeds including the deep-rooted perennial species; it stimulates microbial

activity; it loosens the soil and improves aeration and water infiltration; and it incorporates plant material into the soil which improves the nutrient status and organic content of the soil.

However, plowing and disking of the total plantation area are not always feasible and alternative methods of site preparation must be developed. In the series of experiments described here, we compared the effects on hardwood survival and growth of mechanical and chemical site preparation in strips and of chemical site preparation on individual planting spots.

The widths of the strips were varied to determine the effects of strip width on tree survival and growth as well as the extent of girdling damage of the trees from voles invading the strips from the surrounding weed-infested areas. Plowing three or more furrows from either side to the middle and overlapping the furrow slices in the center of the strips increased the depth of the topsoil and also created a ridge 4-6 in. (10-15 cm) higher than the average level of the land. The furrows on both sides of the strip acted as drainage ditches, thereby improving drainage.

Planting was much easier on the autumn-plowed strips because the overturned sod was largely decomposed, the soil relatively crumbly, and the furrow slices well bonded. These conditions allowed the firming of the soil around the tree roots without much difficulty. In contrast, planting on the spring-plowed strips was much more difficult. The heavy-textured soil was still moist when plowed in early May and the overturned furrow slices formed one long, smooth, continuous band held firmly together by the sod. When this furrow slice was cut with the planting spade the ends of the cut slice tended to pull apart. With little crumbly soil available, it was most difficult and time-consuming to pack the soil firmly around the tree roots. Also, many furrow slices leaned only loosely against each other. Much tramping was therefore required to establish an acceptable bond between the slices. Despite the fact that planting was done more slowly and greater care was taken, many planting slits still opened in the weeks following planting when the soil dried. This exposed the roots to drought or girdling damage by voles (Fig. 4).

Disking improved the consistency of the soil and helped to reduce the air spaces between the furrow slices, but at the same time it destroyed much of the desired ridge effect. While disking of the strips will probably be necessary to prepare the soil for machine planting, a compromise must be found between the maintenance of improved drainage and the requirements of machine planting.

Rototilling a 6-ft (1.8-m)-wide strip in May provided excellent site preparation for planting and chemical weed control. After four passes over the same area the condition of the planting bed was acceptable but an additional two passes produced excellent conditions. Spade

planting by the preferred wedge method was much easier on the rototilled strips than on any of the plowed or control strips and machine planting appeared to be quite feasible after four passes with the rototiller.

Results from agricultural research have shown that on certain soils herbicides may be used as alternatives to plowing without significant reductions in yield of certain crops (Arnott and Clement 1966), but 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. 1973), cottonwoods (McKnight and Biesterfeldt 1968) and paper birch (*Betula papyrifera* Marsh.) (Bjorkbom 1972) but little information is available on the comparative merits of herbicide versus mechanical site preparation in the hardwood afforestation of old fields (Shipman 1974).

The application of herbicides in strips was relatively easy. The measured herbicide-water suspension was broadcast with a motorized mist blower as evenly as possible over the total length of the strip by covering the area two or three times. Application of the herbicides on the individual planting spots was more difficult. Although the hand sprayer had been carefully calibrated, it was difficult to cover the exact number of spots with one sprayer load and thereby ensure the application of the correct herbicide dosage at each spot.

Survival and height growth of all four species planted in Study 3 were significantly better in treatment 11 with site preparation using Gramoxone ® in a 4-ft (1.2-m)-wide strip than in most spot treatments. Survival and height growth of black walnut, white ash, and basswood were also surprisingly high in treatment four which received no site preparation treatment. The poor survival and height growth of all species on the individual planting spots were probably the combined results of the following factors: (1) site preparation and weed control were less effective on the planting spots than in the strips, (2) stem girdling by voles was more severe on the planting spots than on the strips, and (3) the application of Princep ® on the planting spots was uneven and might have damaged white ash, basswood, and cottonwood, but not black walnut, which is highly resistant to Princep ® damage.

From September, 1971 to October, 1975 a study of censusing and control of small mammal populations was carried out by the Canadian Wildlife Service in a white pine plantation with a heavy weed cover located on the same tract as our experiments. These studies showed that the population of meadow voles increased during the summer of 1972 (Radvanyi 1974) and reached a peak in 1975. In May, 1973 when the seedlings of Study 3 were planted, the meadow vole population in the wildlife study area was 58 voles per acre (143/ha). In September of the same year the population had increased to 92 voles per acre (227/ha).

Fig. 4. Exposed white ash root girdled by meadow voles.

Meadow voles destroyed 58% of all cottonwood seedlings during the first 4 weeks after planting and severely damaged another 21% of cottonwood, 28% of white ash, 24% of basswood and 12% of black walnut seedlings. Not only were the killed cottonwood seedlings girdled but stems and roots were eaten as well, leaving only a few 2- to 3-in. (5- to 8-cm) debarked sections of stem lying on the ground.

Vole damage was closely related to site preparation. The most severe damage generally occurred on the individual planting spots and the least damage in the Gramoxone®-sprayed, autumn-plowed and rototilled strips. The greater severity of damage in the spring-plowed strips was probably due to the number of air spaces present between the furrow slices. These spaces provided an excellent shelter for the voles and probably accounted in part for the large number of roots that were girdled in these strips. Only cottonwood seedlings planted in the rototilled strip escaped all girdling damage (Fig. 5).

Since the vole population remained high during the autumn and early winter of 1973, more trees of all species were girdled, and this resulted in an overall survival which was much lower than in most of our previous experimental plantings (von Althen 1974). Girdling damage in Studies 1 and 2 was less severe than in Study 3 because Studies 1 and 2 had no spot treatments, and weed control over 2 or 3 years had resulted in a reduced weed cover. Furthermore, the trees were older and therefore probably less palatable to the voles than were the younger seedlings of Study 3.

CONCLUSIONS AND RECOMMENDATIONS

The results of the three experiments collectively show that survival and height growth of planted black walnut, white ash, basswood and cottonwood seedlings can be significantly improved by site preparation and weed control. Sugar maple survival and height growth were not affected by any of the treatments. The most successful treatments were: rototilling a 6-ft (1.8-m)-wide strip, plowing strips 4 ft (1.2 m) wide or wider, or spraying a 4-ft (1.2-m)-wide strip with Gramoxone®. In each of these treatments a post-planting application of Princep® was applied in each of the first 2 or 3 years after planting. The least successful treatments were the applications of herbicides on individual planting spots.

Planting was easiest on the rototilled and autumn-plowed strips and most difficult on the spring-plowed strips. Since spade planting is uneconomical in most commercial operations, the most suitable site preparation treatments for machine planting appear to be rototilling, spraying, and autumn plowing and disking of strips.

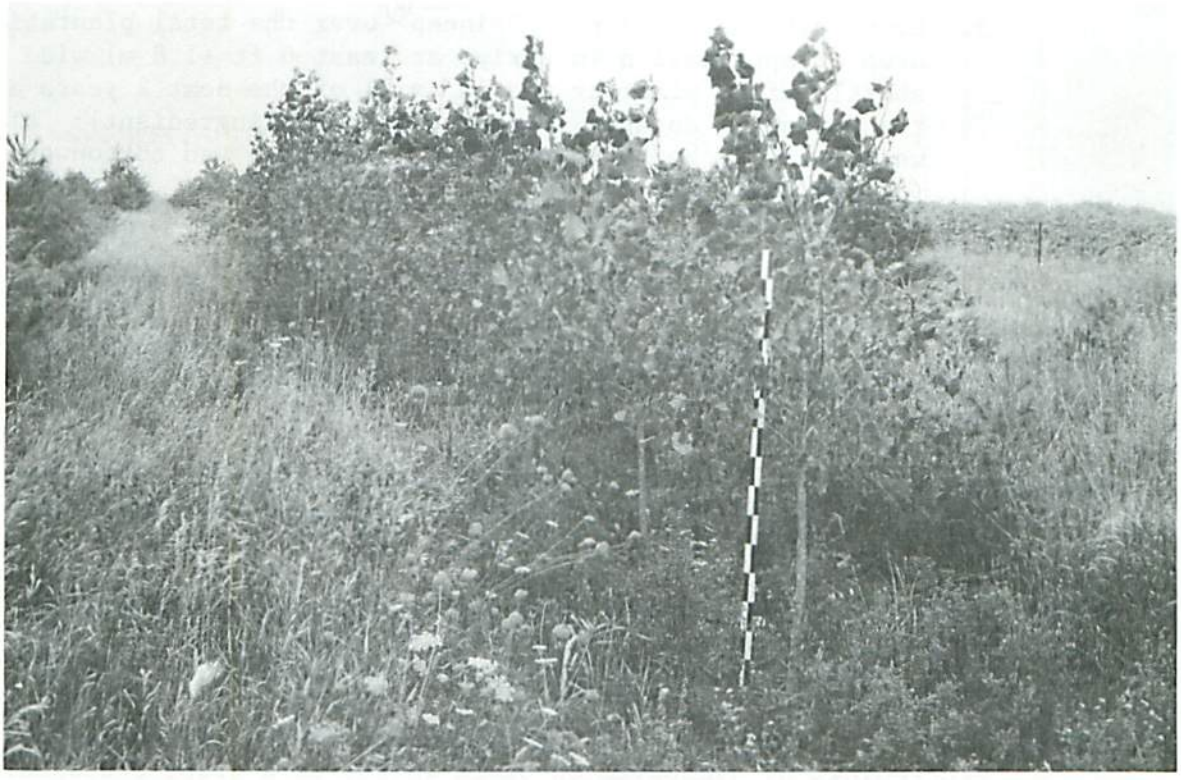

Fig. 5. Three-year-old cottonwood planted in rototilled strip.

Stem girdling of the hardwood seedlings by meadow voles was most severe on the control plots, the individual planting spots and the narrowest strips, and least severe in the rototilled strips. Cottonwood was the most severely attacked, followed by white ash, sugar maple, basswood and black walnut.

On the basis of the results of these and previous studies (von Althen 1971, 1974, 1975), the following recommendations are made for afforesting old fields in southern Ontario with black walnut, white ash, basswood, and cottonwood. (The planting of sugar maple in old fields cannot be recommended at this time.)

1. Plowing and disking of the total plantation area or, where this is not feasible, either rototilling, autumn plowing, or spraying of Gramoxone ® in spring shortly before planting in strips 6 ft (1.8 m) wide or wider if possible.

2. Wedge or machine planting of large, healthy seedlings in early spring.

3. Broadcast application of Princep® over the total plantation area or application in strips at least 6 ft (1.8 m) wide shortly after planting and in April of the next 2 years at the following dosages (lb/acre of active ingredient): black walnut 6 (6.7 kg/ha), white ash, basswood, and cottonwood 3 (3.4 kg/ha).

LITERATURE CITED

Arnott, R.A. and C.R. Clement. 1966. The use of herbicides in alternative husbandry as a substitute for ploughing. Weed Res. 6:142-157.

Bjorkbom, J.C. 1972. Ten-year growth of planted paper birch in old fields in Maine. USDA For. Serv., Northeast. For. Exp. Stn. Res. Pap. NE-246. 6 p.

Byrnes, W.R. 1966. Site preparation and weed control. Proceedings of a workshop on black walnut culture, Carbondale, Ill. Aug. 1966. USDA For. Serv., North Central For. Exp. Stn., p. 20-27.

Byrnes, W.R., J.E. Krajicek, and J.R. Wichmann. 1973. Weed control. Proceedings of symposium on black walnut as a crop, Carbondale, Ill. Aug. 1973. USDA For. Serv., North Central For. Exp. Stn. Gen. Tech. Rep. NC-4. p. 42-48.

Dowdell, R.J. and R.Q. Cannell. 1975. Effect of ploughing and direct drilling on the soil nitrate content. J. Soil Sci. 26:53-61.

Fitzgerald, C.H., F.A. Peery, and D.E. Fender. 1973. Rehabilitation of forest land: The Southern Region. J. For. 71:148-153.

McKnight, J.W. and R.C. Biesterfeldt. 1968. Commercial cottonwood planting in the southern United States. J. For. 66:670-675.

Radvanyi, A. 1974. Survey and control of small mammal populations on two hardwood plantations in southern Ontario. For. Chron. 50: 181-185.

Shipman, R.D. 1974. Preparing planting sites with herbicides. USDA For. Serv. Tree Plant. Notes 26:1-4.

Steel, G.D. and J.H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill, New York. 107-109.

von Althen, F.W. 1971. Site preparation and weed control in white ash and black walnut afforestation. Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-153. 13 p.

von Althen, F.W. 1972. Preliminary guide to hardwood planting in southern Ontario. Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-167. 12 p.

von Althen, F.W. 1974. Planting trials with black walnut and white ash transplants in southern Ontario. Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-190. 15 p.

von Althen, F.W. 1975. Black walnut seeding versus planting in a plantation with Princep ® weed control. Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-218. 7 p.