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PLANTING STUDIES WITH HYBRID POPLARS AND COTTONWOOD IN SOUTHWESTERN ONTARIO

F. W. VON ALTHEN

GREAT LAKES FOREST RESEARCH CENTRE
SAULT STE. MARIE, ONTARIO

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ABSTRACT

This report presents 5-year results of one study comparing survival and growth of unrooted cuttings of 26 hybrid poplar (*Populus* spp.) clones, and seedlings and unrooted cuttings of cottonwood (*P. deltoides* Bartr.) under different intensities of weed control, as well as 3-year results of two studies comparing survival and growth of cottonwood when different intensities of weed control and different types of planting stock were used. All studies were carried out in a former field located near Shipka, Stephan Township, Huron County, Ontario. The soil was imperfectly drained sandy loam, very moist in early spring as a result of heavy runoff from an adjacent woodlot.

Unrooted cuttings were planted by dibble; rooted cuttings and seedlings were planted by spade. Site preparation consisted of plowing in Study 1 and plowing and disking of the total area in Studies 2 and 3. Weed control treatments were applied in each of the first three years after planting.

Simazine applied shortly after planting at dosages of more than 2.2 kg/ha of active ingredient inhibited the rooting of cuttings of cottonwood and most hybrid poplar clones and reduced survival of cottonwood seedlings. Resistance to simazine injury by unrooted cuttings of most hybrid poplar clones and cottonwood cuttings and seedlings increased with years since planting. Applications of 4.5 kg/ha of simazine in spring of the second year and 4.5 or 6.6 kg/ha of simazine in spring of the third year caused no injury to the young trees.

Height and diameter, 5 years after planting, varied widely between individual hybrid poplar clones and between the clones and cottonwood seedlings and cuttings. All clones and the cottonwood seedlings and cuttings were rated according to their 5-year survival, height, and diameter and were ranked in order of performance.

Rooted cuttings and seedlings of cottonwood survived and grew significantly better than unrooted cuttings or the stems of decapitated rooted cuttings and seedlings planted as whips. Decapitation of rooted cuttings and seedlings shortly after planting had little effect on 3-year survival and growth.

RÉSUMÉ

Ce rapport présente les résultats en 5 ans d'une étude de comparaison de la survie et de la croissance des boutures non racinées de 26 clones de peupliers hybrides (*Populus* spp.) et des semis et boutures non racinées du liard (*P. deltoides* Bartr.) traités à différents niveaux de désherbage, ainsi que les résultats en 3 ans de deux autres études de comparaison de la survie et de la croissance du liard lorsque différents niveaux de désherbage et types de semis étaient utilisés. Toutes ces études ont été effectuées dans un ancien champ situé près de Shipka, Township de Stephan, Comté de Huron (Ontario). Le sol de ce champ était un loam sablonneux imparfaitement drainé, très humide au début du printemps à cause d'un écoulement d'eau provenant d'un boisé limitrophe.

Les boutures non racinées ont été plantées au bâton et les boutures racinées et les semis à la bêche. La préparation du terrain a consisté à labourer le site de l'étude 1 et à labourer puis à passer à la charrue à disques ceux des études 2 et 3. Les traitements de désherbage ont été administrés à chacune des trois premières années consécutives à la plantation.

Administrée peu après la plantation à des doses supérieures à 2.2 kg/ha d'ingrédient actif, la simazine a inhibé le racinement des boutures du liard et de la plupart des clones de peupliers hybrides et réduit la survie des semis du liard. La résistance des boutures non racinées de la plupart des clones de peupliers hybrides ainsi que des boutures et semis du liard aux méfaits de la simazine s'est renforcée au fil des années subséquentes à la plantation. Des doses de 4.5 kg/ha de simazine administrées au début du printemps de la seconde année et de 4.5 ou 6.6 kg/ha de simazine au printemps de la troisième année n'ont fait aucun mal aux jeunes arbres.

La hauteur et le diamètre mesurées 5 ans après la plantation variaient considérablement entre les différents clones de peupliers hybrides et entre les clones et les semis et boutures du liard. Tous les clones et tous les semis et boutures du liard ont été évalués en fonction de leur survie, hauteur et diamètre à 5 ans puis classés selon leur ordre de performance.

La survie et la croissance des boutures racinées et semis du liard ont été significativement meilleures que celles des boutures racinées ou des tiges des boutures étêtées racinées et des semis plantés comme fouets. L'étêtage des boutures racinées et des semis peu après la plantation n'a eu que peu d'effet sur la survie et la croissance à 3 ans.

Frontispiece

a) Five-year-old hybrid poplar of clone D22.

b) Three-year-old cottonwood poplar planted as unrooted cutting.

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INTRODUCTION

Very few poplar plantations have been established in southwestern Ontario. There are several reasons for this. In the first place, most planting sites that were available in the past were relatively fertile and it was deemed more profitable to plant upland hardwoods or conifers. In the second place, few industries were interested in poplar lumber or pulpwood, nor were they equipped to utilize them. Further, during the last decade, farming in southwestern Ontario has become increasingly more profitable with the result that formerly abandoned fields, which were available for afforestation, are now being farmed. With few exceptions the only planting sites still available are slopes or imperfectly drained areas too steep or too wet for profitable farming. While the slopes will generally support plantations of upland hardwoods or conifers, poplars appear to be best for afforesting imperfectly drained sites.

Beginning in 1976 a series of experiments was carried out to determine the suitability of hybrid poplar (*Populus* spp.) clones and cottonwood (*P. deltoides* Bartr.) seedlings and cuttings for afforesting imperfectly drained, abandoned agricultural land in southwestern Ontario. This report presents the 5-year results of one study which compared the survival and growth of 26 hybrid poplar clones and cottonwood seedlings and cuttings subjected to different intensities of weed control and the 3-year results of two studies which compare the survival and growth of cottonwoods subjected to different intensities of weed control and grown from different types of planting stock.

AREA

The experimental site was a former field located near Shipka, Stephan Township, Huron County, Ontario. The soil was imperfectly drained sandy loam over clay till at a depth of 40 to 60 cm. The pH of the plow layer was 7.5 and organic matter content was 3.6%. The Ontario Soil Survey (Hoffman et al. 1952) classifies the soils as Barrien sandy loam which is the imperfectly drained member of the *Bookton catena*.

The field was farmed until the autumn prior to spring planting but was retired from farming because imperfect drainage, together with runoff from an adjacent woodlot, greatly delayed spring planting and made harvesting difficult.

METHOD

Study 1

Following the harvest of a corn crop the experimental area was plowed in the autumn of 1975. In April of 1976 unrooted cuttings, each 25 cm long, of 26 hybrid poplar clones, unrooted cottonwood cuttings, each 30 cm long, and 2 + 0 cottonwood seedlings with stems averaging 60 cm in length were planted by dibble and spade, respectively at a spacing of 3 x 3 m.

Treatments consisted of:

1. Rototilling between trees four times per summer in each of the first 3 years after planting.

2. Broadcast applications of 2.2 kg/ha of active simazine shortly after planting and in April of years 2 and 3.

3. One broadcast application of 2.2 kg/ha of active simazine shortly after planting and broadcast applications of 4.5 kg/ha of active simazine in April of years 2 and 3.

4. Broadcast applications of 4.5 kg/ha of active simazine shortly after planting and in April of years 2 and 3.

5. One broadcast application of 2.2 kg/ha of active simazine shortly after planting and broadcast applications of 4.5 kg/ha and 6.6 kg/ha of active simazine in April of years 2 and 3, respectively.

No untreated plots were established because previous experiments had shown that few cuttings or seedlings survived or grew well without some type of weed control (Kennedy 1975, von Althen 1979a).

All hybrid poplar cuttings were supplied by A. Zsuffa of the Ontario Ministry of Natural Resources while the cottonwood cuttings and seedlings were supplied by the St. Williams nursery of the Ontario Ministry of Natural Resources.

The experiment was laid out in randomized block arrangement with four cuttings of each of 26 hybrid poplar clones (Appendix) and four cuttings and four seedlings of cottonwood in each of four treatments. Because of a shortage of planting stock, treatment 5 contained four cuttings of each of 10 hybrid poplar clones plus four cuttings and four seedlings of cottonwood. There were three replications, for a total of 48 cuttings per clone, planted in four treatments, and 60 cuttings per clone and 60 cuttings and 60 seedlings of cottonwood, planted in five treatments.

Effectiveness of weed control treatments was assessed by ocular estimate in June and August of each year.

Survival and height were recorded in the autumn of the first year after planting and survival, height and breast height diameter were recorded in the autumn of the fifth year after planting. Survival data were subjected to chi-square tests of independence and the 5-year height and diameter data to analysis of variance and Tukey's tests of significance.

Study 2

The experiment was carried out in the same field as Study 1. The experimental area was plowed in the autumn of 1975 and disked several times during the summer of 1976. In April 1977 unrooted cottonwood cuttings, each 30 cm long, and 2 + 0 cottonwood seedlings with an average stem length of 90 cm were planted by dibble and spade, respectively, at a spacing of 3 m between rows and 1.5 m within rows.

Treatments consisted of:

1. Rototilling between rows four times per year for the first 3 years after planting.

2. Rototilling between rows four times during the summer of the first year and broadcast applications of 2.2 kg/ha of active simazine in April of years 2 and 3.

3. Rototilling between rows four times during the summer of the first year and broadcast applications of 3.3 kg/ha of active simazine in April of years 2 and 3.

4. Broadcast applications of 2.2 kg/ha of active simazine shortly after planting and in April of years 2 and 3.

5. One broadcast application of 2.2 kg/ha of active simazine shortly after planting and applications of 3.3 kg/ha of active simazine in April of years 2 and 3.

6. Broadcast applications of 3.3 kg/ha of active simazine shortly after planting and in April of years 2 and 3.

All cuttings and seedlings were supplied by the St. Williams nursery of the Ontario Ministry of Natural Resources.

The experiment was laid out in randomized block arrangement with 15 cuttings and seedlings per treatment. Each treatment was replicated four times for a total of 60 cuttings and seedlings.

Effectiveness of weed control treatments was assessed by ocular estimate in June and August of each year.

Survival and height were recorded in the autumn of the first and third year after planting. Third year survival data were subjected to chi-square tests of independence and the third year height data to analysis of variance and Tukey's tests of significance.

Study 3

The experiment was carried out in the same field as studies 1 and 2. The experimental area was plowed in the autumn of 1975 and disked several times during the summers of 1976 and 1977. In April 1978 unrooted cottonwood cuttings were planted by dibble and rooted cottonwood cuttings and 2 + 0 seedlings were planted by spade. Within hours after planting the stems of half of the rooted cuttings and seedlings were cut at a height of 2.5 cm above ground. The cut stems were then planted by dibble at a depth of 30 cm. Spacing was 3 m between rows and 1.5 m within rows.

Treatments consisted of:

1. Planting of rooted cuttings with average stem lengths of 80 cm.

2. Planting of rooted cuttings and decapitation of the stems, shortly after planting, at a height of 2.5 cm above ground.

3. Planting of the cut stems of the rooted cuttings at a depth of 30 cm.

4. Planting of 2 + 0 seedlings with average stem lengths of 60 cm.

5. Planting of 2 + 0 seedlings and decapitation of the stems, shortly after planting, at a height of 2.5 cm above ground.

6. Planting the cut stems of the 2 + 0 seedlings at a depth of 30 cm.

7. Planting unrooted cuttings 30 cm long.

All cuttings and seedlings were supplied by the St. Williams nursery of the Ontario Ministry of Natural Resources.

The experiment was laid out in randomized block arrangement with 12 trees per treatment. Each treatment was replicated six times for a total of 72 trees per planting stock type.

Weed control consisted of rototilling between rows four times per summer in each of the first 2 years after planting and one broadcast application of 4.5 kg/ha of active simazine in April of the third year after planting.

Survival and height were recorded in the autumn of the first and third years after planting. Survival data were subjected to chi-square tests of independence and height data to analysis of variance and Tukey's tests of independence.

RESULTS

Study 1

Rototilling in two directions four times per year in each of the first 3 years after planting provided good weed control except for a buffer of approximately 60 x 60 cm around each tree (Table 1). A dense weed cover developed in this area and competed vigorously with the young trees for the first 2 years. Thereafter, the shade of the tree crowns suppressed vigorous weed growth.

Annual applications of 2.2 kg/ha of active simazine in each of the first 3 years after planting delayed establishment of a dense weed cover but were unable to prevent serious competition from quackgrass (*Agropyron repens* L. Beaur.); Canada thistle (*Cirsium arvense* L. Scop) and milkweed (*Asclepias syriaca* L.) in the second and later years.

Applications of 2.2 kg/ha of active simazine shortly after planting and 4.5 kg/ha in April of the second and third growing seasons provided 60% weed control during the first 3 years and 30% control in the fourth year.

Annual applications of 4.5 kg/ha of active simazine allowed the establishment of only scattered patches of quackgrass, Canada thistle and milkweed. Following discontinuation of the weed control treatments after the third year, the invasion of weeds was noticeably slower in these than in the rototilled plots.

Successive applications of 2.2, 4.5 and 6.6 kg/ha of simazine in years 1, 2 and 3, respectively, provided only slightly better weed control than applications of 2.2 kg/ha in the first year and 4.5 kg/ha in years 2 and 3 (treatment 3), but the carry-over into year 4 was slightly stronger (see Frontispiece, a).

Average survival of all clones and the cottonwood seedlings and cuttings was significantly lower in treatment 4 than in all other treatments (Table 2). With the exception of clones D37 and DJac14 and the cottonwood cuttings, average survival of all hybrid poplars and the cottonwoods was 70% or better. Within individual clones and the cottonwoods, treatments significantly affected the survival of only clones DN30, DJac14, DTac1 and I-65A. The main cause of mortality of all clones and the cottonwood cuttings was their inability to root. Once the trees were rooted, very few died between the first and fifth years.

Table 1. Effectiveness of weed control treatments.

STUDY 1

Years since planting	Percent control (treatments in parentheses)[a]				
1st year	80 (rototilled)	60 (2.2 kg/ha)	60 (2.2 kg/ha)	80 (4.5 kg/ha)	60 (2.2 kg/ha)
2nd year	80 (rototilled)	40 (2.2 kg/ha)	60 (4.5 kg/ha)	80 (4.5 kg/ha)	60 (4.5 kg/ha)
3rd year	80 (rototilled)	20 (2.2 kg/ha)	60 (4.5 kg/ha)	80 (4.5 kg/ha)	70 (6.6 kg/ha)
4th year	20	0	30	40	40

STUDY 2

Years since planting	Percent control (treatments in parentheses)[a]					
1st year	80 (rototilled)	80 (rototilled)	80 (rototilled)	60 (2.2 kg/ha)	60 (2.2 kg/ha)	60 (3.3 kg/ha)
2nd year	80 (rototilled)	50 (2.2 kg/ha)	60 (3.3 kg/ha)	40 (2.2 kg/ha)	50 (3.3 kg/ha)	60 (3.3 kg/ha)
3rd year	90 (rototilled)	30 (2.2 kg/ha)	60 (3.3 kg/ha)	20 (2.2 kg/ha)	50 (3.3 kg/ha)	60 (3.3 kg/ha)

[a] All treatments except rototilling were with simazine.

Table 2. First- and fifth-year survival of hybrid poplar cuttings and cottonwood seedlings and cuttings by weed control treatments.

Hybrid poplar clones and cottonwood seedlings and cuttings		First-year survival (%)					Fifth-year survival (%)				
		1	2	3	4	5	1	2	3	4	5
			Simazine					Simazine			
	1st year	Rototilled	2.2 kg/ha	2.2 kg/ha	4.5 kg/ha	2.2 kg/ha	Rototilled	2.2 kg/ha	2.2 kg/ha	4.5 kg/ha	2.2 kg/ha
	2nd year	Rototilled	2.2 kg/ha	4.5 kg/ha	4.5 kg/ha	4.5 kg/ha	Rototilled	2.2 kg/ha	4.5 kg/ha	4.5 kg/ha	4.5 kg/ha
	3rd year	Rototilled	2.2 kg/ha	4.5 kg/ha	4.5 kg/ha	6.6 kg/ha	Rototilled	2.2 kg/ha	4.5 kg/ha	4.5 kg/ha	6.6 kg/ha
D37		58*	67	42	42	75	37	67	42	42	75
D68		100	92	100	92	100	100	92	100	92	100
D70		75	67	75	58	83	67	67	75	58	83
DN19		100	92	100	75	75	100	92	100	67	75
DN21		100	100	92	67	87	92	100	83	67	83
DN30		100a	100a	92ab	75b	100a	100a	100a	92ab	75b	100a
DJac14		100a	67ab	67ab	46b	25b	100a	62ab	62ab	46b	25b
I-45/51		100	100	75	75	92	75	75	67	75	83
I-214		100	100	83	67	100	100	100	83	67	100
C147		83	75	83	63	87	83	75	83	58	83
Cottonwood cuttings		67	58	58	37	58	50	42	58	37	58
Cottonwood seedlings		92	100	100	75	92	92	92	100	67	92
Mean of 10 clones and cottonwoods planted in five treatments		90a	85a	81a	64b	81a	83a	80a	79a	63b	80a
D38		92	92	92	83	–	92	92	92	67	–
D52		92	100	92	67	–	92	100	92	67	–
DN1		100	92	75	83	–	100	92	75	75	–
DN2		92	92	75	83	–	92	92	67	75	–
DN5		92	83	75	83	–	83	75	75	67	–
DN10		83	92	83	67	–	83	92	83	67	–
DN16		92	92	92	67	–	83	92	92	67	–
DN17		100	92	92	100	–	100	92	92	92	–
DN18		100	83	58	58	–	100	83	58	50	–
DN20		92	92	67	75	–	83	75	58	75	–
DN22		92	100	83	75	–	83	100	83	75	–
DN23		67	100	92	92	–	58	100	92	92	–
DN31		100	100	83	75	–	100	100	75	75	–
DN38		100	75	83	92	–	100	75	75	92	–
DTac1		92ab	100a	75ab	67b	–	92ab	100a	67b	67b	–
I-65A		100a	75ab	75ab	50b	–	100a	75ab	75ab	37b	–
Mean of 16 clones planted in four treatements		93a	91a	81ab	76b	–	90a	90a	78ab	71b	–
Mean of all 26 clones and cottonwoods		91a	89a	81a	70b	–	87a	86a	78a	67b	–

Note: Within hybrid poplar clones and cottonwoods means followed by different letters differ significantly ($p \leq 0.05$)

*Data are means of 12 trees

Average height of all clones and cottonwoods planted in four treatments was significantly lower in treatment 3 than in the other treatments (Table 3). Within the 10 clones and the cottonwoods planted in five treatments, average height was significantly lower in treatment 5 than in treatments 1, 2 and 4. Within individual clones and the cottonwoods, treatments significantly affected the DBH of only clone D70 and the cottonwood cuttings.

Study 2

Rototilling four times per year between rows in each of the first 3 years after planting provided at least 80% weed control (Table 1). Weeds started to grow within the rows, but since the trees were spaced only 1.5 m apart, crown closure during the second year eliminated most of the competition. Rototilling four times per year between rows in the first year after planting, followed by simazine applications of either 2.2 or 3.3 kg/ha in years 2 and 3, provided acceptable weed control. The 3.3 kg/ha dosage provided noticeably better weed control than the 2.2 kg/ha dosage. Annual applications of 2.2 kg/ha of simazine were insufficient to prevent the establishment of a dense cover of mainly quackgrass and milkweed. Applications of 2.2 kg/ha of simazine in year 1 and 3.3 kg/ha in years 2 and 3 provided slightly better weed control than applications of 2.2 kg/ha of simazine. However, the quackgrass which became established in the first year was not eradicated nor was its growth greatly inhibited by applications of 3.3 kg/ha of simazine in years 2 and 3. Annual applications of 3.3 kg/ha of simazine provided 60% weed control in each year of application.

Weed control treatments had no effect on either survival or height of cottonwood cuttings (Table 4). Seedling survival was significantly greater than survival of cuttings in five out of six treatments. Average survival of seedlings was significantly greater in treatment 2 following rototilling during the first year and applications of 2.2 kg/ha of simazine in the second and third years after planting than in all other treatments. Annual applications of 3.3 kg/ha of simazine in each of the first 3 years after planting (treatment 6) significantly reduced seedling survival.

Seedlings were significantly taller in all treatments where the soil had been rototilled for at least one year than in treatments 4 and 5, which had received only chemical weed control. There was no significant difference in height, 3 years after planting, between cuttings and seedlings, despite a 90 cm height advantage of the seedlings at time of planting.

Table 3. Five-year height and DBH of hybrid poplar cuttings and cottonwood seedlings and cuttings by weed control treatments.

Hybrid poplar clones and cottonwood seedlings and cuttings		Height (m)					DBH (cm)				
		1	2	3	4	5	1	2	3	4	5
			Simazine					Simazine			
	1st year	Rototilled	2.2 kg/ha	2.2 kg/ha	4.5 kg/ha	2.2 kg/ha	Rototilled	2.2 kg/ha	2.2 kg/ha	4.5 kg/ha	2.2 kg/ha
	2nd year	Rototilled	2.2 kg/ha	4.5 kg/ha	4.5 kg/ha	4.5 kg/ha	Rototilled	2.2 kg/ha	4.5 kg/ha	4.5 kg/ha	4.5 kg/ha
	3rd year	Rototilled	2.2 kg/ha	4.5 kg/ha	4.5 kg/ha	6.6 kg/ha	Rototilled	2.2 kg/ha	4.5 kg/ha	4.5 kg/ha	6.6 kg/ha
D37		5.6*	6.0	4.8	6.8	4.3	5.3	6.6	4.5	7.1	4.6
D68		6.8	7.5	6.9	6.4	7.0	9.1	11.0	9.6	8.9	9.5
D70		6.4	7.9	6.4	7.1	7.0	8.5ab	10.0a	7.1b	9.7a	8.7ab
DN19		6.4	7.1	7.0	7.1	6.9	7.4	10.0	9.7	11.3	10.2
DN21		7.1a	6.9a	4.9b	7.1a	5.3b	7.6	7.8	4.5	8.7	5.6
DN30		6.7	7.1	6.8	7.4	5.6	8.2	8.1	7.9	9.9	8.0
DJac14		5.4	6.1	5.5	5.0	3.4	6.2	7.3	6.1	5.5	3.0
I-45/51		7.4	6.6	7.2	7.6	7.0	8.1	6.4	7.2	9.2	9.1
I-214		6.7	6.1	6.9	6.3	6.4	6.7	6.3	7.6	7.8	7.6
C147		6.3	5.8	5.5	6.1	5.0	6.4	5.5	5.6	5.5	5.2
Cottonwood cuttings		5.8b	6.5ab	6.4ab	7.5a	5.5b	5.6b	6.8ab	7.0ab	8.2a	6.2ab
Cottonwood seedlings		6.8	7.1	6.6	7.4	7.1	8.1	9.7	8.0	10.0	9.1
Mean of 10 clones and cottonwoods planted in four treatments		6.5a	6.7a	6.2ab	6.8a	5.9b	7.3b	8.0a	7.1b	8.5a	7.2b
D38		8.3	7.6	7.5	6.9	-	9.3	7.7	8.8	7.0	-
D52		8.2a	6.8b	6.7b	8.0a	-	9.2	7.2	7.0	9.5	-
DN1		7.4	6.9	6.8	7.1	-	7.7	7.3	7.7	7.6	-
DN2		6.7b	8.2a	6.6b	7.4ab	-	6.9	8.9	6.8	8.1	-
DN5		5.2b	6.4	5.7	6.7	-	4.5	6.6	6.3	6.9	-
DN10		7.4	7.4	6.8	6.4	-	7.6	7.2	6.8	6.4	-
DN16		6.7	6.9	5.7	6.5	-	7.9	8.0	6.3	8.0	-
DN17		6.4	7.5	6.5	6.4	-	6.4	7.9	6.1	5.9	-
DN18		5.8	6.1	4.7	4.7	-	6.1	6.2	4.3	4.9	-
DN20		5.7	6.0	5.8	6.1	-	6.9	6.8	6.8	8.1	-
DN22		7.9	6.9	7.2	7.3	-	9.3	7.3	8.1	9.8	-
DN23		6.1	5.9	6.2	5.9	-	6.8	6.8	7.1	7.1	-
DN31		6.6	5.7	6.1	7.1	-	8.1	5.6	6.7	6.9	-
DN38		7.9	7.2	7.2	7.8	-	9.7	8.1	8.5	9.6	-
DTac1		7.4	6.4	6.2	6.0	-	8.3	7.2	7.4	6.9	-
I-65A		7.0	6.1	6.0	7.7	-	8.9	7.1	7.0	9.6	-
Mean of 16 clones planted in four treatments		6.9a	6.8a	6.3b	6.8a	-	7.7a	7.2ab	7.0b	7.6a	-
Mean of all 26 clones and cottonwood		6.7ab	6.7ab	6.3b	6.8a	-	7.5ab	7.6ab	7.0b	8.0a	-

Note: Within hybrid poplar clones and cottonwoods means followed by different letters differ significantly ($p \leq 0.05$)

*Data are means of 12 trees

Table 4. Three-year survival and height of cottonwood cuttings and seedlings by weed control treatments.

Treatment	Survival (%)		Height (cm)	
	Cuttings	Seedlings	Cuttings	Seedlings
1. Rototilling for 3 years	40*a	65b	347a	375a
2. Rototilling in year 1, 2.2 kg/ha of simazine in years 2 and 3	42a	33a	344a	352ab
3. Rototilling in year 1, 3.3 kg/ha of simazine in years 2 and 3	35a	73b	319a	345ab
4. 2.2 kg/ha of simazine for 3 years	42a	68b	291a	282c
5. 2.2 kg/ha of simazine in year 1 and 3.3 kg/ha in years 2 and 3	50a	60b	271a	282c
6. 3.3 kg/ha of simazine for 3 years	42a	48c	273a	315c

Lines connect means that are significantly different at the 5% level
For cuttings and seedlings separately, treatment means lacking a common letter differ significantly ($p \leq 0.05$)

*Data are means of 60 trees

Study 3

The average first-year survival of the rooted cuttings and 2 + 0 seedlings with stems intact or with stems decapitated shortly after planting was significantly greater than the average survival of unrooted cuttings or planted stems of the decapitated rooted cuttings and seedlings (Table 5). Survival of cut stems of the 2 + 0 seedlings (treatment 6) was significantly greater than that of unrooted cuttings (treatment 7) or the cut stems of the rooted cuttings (treatment 3). Average survival of unrooted cuttings (treatment 7) was significantly greater than that of the cut stems of the rooted cuttings (treatment 3). There was no significant difference between first- and third-year survival of any of the different types of stock planted.

Three years after planting no significant difference was found in average height between rooted cuttings (treatment 1) and 2 + 0 seedlings which had been planted with their tops intact (treatment 4) and those that had been decapitated shortly after planting (treatment 5). Total height of unrooted cuttings (treatment 7) was significantly lower, 3 years after planting, than that of rooted cuttings (treatment 1) and seedlings with stems (treatment 4) and the planted stems cut from the seedlings (treatment 6) and rooted cuttings (treatment 3). However, this difference was significant only because the total height does not reflect the height at time of planting. There was no significant difference in the 3-year height growth between any of the different types of planting stock (see Frontispiece, b).

Table 5. First- and third-year survival and third-year height of cottonwood rooted and unrooted cuttings, 2 + 0 seedlings and stems from decapitated rooted cuttings and 2 + 0 seedlings.

Treatment	Survival 1st year	Survival 3rd year	Third year total height	Three-year height growth
	(%)	(%)	(cm)	(cm)
1. Rooted cuttings with stems 30 cm long	94*a	90a	413a	333a
2. Rooted cuttings with stems cut 2.5 cm above the ground	97a	96a	340ab	337a
3. Stems of rooted cuttings inserted 25 cm into the soil	47d	47d	387a	332a
4. 2 + 0 seedlings with stems 60 cm long	97a	97a	405a	345a
5. 2 + 0 seedlings with stems cut 2.5 cm above ground	91a	36a	352ab	349a
6. Stems of 2 + 0 seedlings inserted 25 cm into the soil	83b	79b	405a	370a
7. Unrooted cuttings 30 cm long	67c	62c	305b	305a

Means lacking a common letter differ significantly ($p \leq 0.05$)

*Data are means of 72 trees

DISCUSSION

It has long been recognized that competition from broadleaved weeds and grasses adversely affects the survival and growth of planted poplars (Schreiner 1945, Hesmer 1951). Although a dense cover of sod may kill newly planted trees (Schreiner 1940), Aird (1962) found that the presence of weeds significantly decreased root, shoot and volume growth, number and weight of leaves, and foliar composition.

Until recently the most widely used method of site preparation was plowing and disking of the total plantation area. Postplanting weed control consisted of disking or rototilling between the trees (Zsuffa et al. 1977). However, such methods are labor-intensive and therefore expensive.

Polyethylene mulch has been tested as an alternative to mechanical weed control. Bowersox and Ward (1970) found that during periods of average rainfall the mulched trees had lower mortality and greater shoot growth. However, during a season of prolonged drought the polyethylene film hindered the recharge of soil moisture by light rainfalls, nullifying the earlier growth advantage. Although establishment success with polyethylene mulch may equal or exceed that achieved by mechanical weed control, the material is expensive and its application is labor-intensive.

The recent development of a wide selection of herbicides increases the potential for economical weed control. Before the widespread use of herbicides can be recommended, however, the tolerance of individual poplar species and clones to different herbicides and dosages must be established.

Simazine is one of the more promising herbicides because it has proven very effective in the control of weed competition in upland hardwood plantations (von Althen 1976, 1979a). It has also been tested for weed control in poplar plantations but results obtained have varied widely. Cunningham and Sowers (1965) stated that simazine was no substitute for cultivation in hybrid poplar plantations because application rates of 2.2 kg/ha or more greatly reduced the survival of hybrid poplar clones. Martin and Carter (1966) found good growth and survival of cottonwood cuttings following application of up to 13.5 kg of simazine per ha. Geyer (1974) reported that 1.1 kg of simazine sprayed in 61-cm-wide strips on a sandy loam soil killed nearly 75% of planted 1 + 0 cottonwood seedlings. Dickman et al. (1977) found that simazine applications up to 4.5 kg/ha did not reduce the survival of unrooted poplar cuttings planted 3 weeks after the simazine had been applied. Netzer and Noste (1978) applied simazine at dosages of 2.2-6.7 kg/ha on a nursery site, a sod site, and a clearcut site. Unrooted poplar cuttings or cuttings prerooted in styrofoam blocks were planted 5 days after the simazine applications. Following the 2.2 kg/ha application, second-year survival was 77, 29, and 63%, respectively, in the nursery, the sod and the clearcut. The application of 6.7 kg/ha of simazine reduced 2-year survival to 38, 8, and 17%, respectively, in the nursery, the sod, and the clearcut.

In comparing survival of unrooted cuttings of different hybrid poplar clones, I found that susceptibility to simazine injury varied widely between clones (von Althen 1979a). While cuttings of some clones failed to root following application of 2.2 kg/ha of simazine, other clones had near perfect survival following application of 4.5 kg/ha.

The survival figures in Table 2 show that 4.5 kg/ha of simazine, applied shortly after planting, greatly reduced survival of unrooted cuttings of cottonwood and many hybrid poplar clones. The main cause of mortality was failure of the cuttings to root rather than failure to survive after rooting. When 4.5 kg/ha of simazine were applied in the second or third years after planting, survival was not affected. Also, the first-year survival of the 2 + 0 cottonwood seedlings was much higher than that of unrooted cottonwood cuttings. This indicates that resistance of cottonwood and hybrid poplar cuttings to simazine injury increases with years since planting. In Study 1 the mean survival of all hybrid poplar cuttings and cottonwood cuttings and seedlings was significantly reduced by applying 4.5 kg/ha of simazine shortly after planting. However, significant differences in survival of individual clones between the 4.5 kg/ha application shortly after planting and the rototilling treatment occurred only in clones DN30, DJac14 and I-65A. The reason for the lack of statistically significant differences is believed to be the small number of cuttings planted and the small number of replications per treatment. More trees per treatment and more replications would probably have identified more clones with statistically significant differences in survival between the rototilling treatment and the 4.5 kg/ha application of simazine shortly after planting. While clones like D68, DN17 and DN23 showed high resistance to simazine injury, it appears advisable to limit applications of simazine at time of planting to 2.2 kg/ha in all plantings except where planting is restricted to clones with proven resistance to simazine injury. On sites requiring dosages of more than 2.2 kg/ha of simazine to control weeds, mortality may be reduced by applying simazine several weeks prior to planting or by planting rooted cuttings or seedlings rather than unrooted cuttings.

Although 5-year height and diameter of individual clones and cottonwood seedlings and cuttings varied widely between treatments, mean height and diameter of all clones and cottonwood seedlings and cuttings were very similar for all treatments. Greatest mean height and diameter were recorded in treatment 4, in which 4.5 kg/ha of simazine were applied in 3 successive years. This was the treatment with the best weed control, but the lowest mean survival. The significantly lower mean height and diameter in treatment 3 cannot be explained since weed control in this treatment was superior to that in treatment 2, and according to the established trend, this should have resulted in greater mean height and diameter.

One of the objectives of this study was to determine the suitability of individual hybrid poplar clones and cottonwood seedlings and cuttings for the afforestation of imperfectly drained sites in southwestern Ontario. Since different clones have different growth characteristics, i.e., some grow tall, others short, some have large, others small diameters, some root and survive well, others root or survive poorly, no single characteristic can be used to evaluate growth properly. Hybrid poplar clones and cottonwood seedlings and cuttings of treatments 1 to 3 (total of 36 trees per clone and cottonwood age class) were therefore rated according to two indices. The first index evaluated clones and cottonwoods according to the formula: $DBH^2 \times ht$ where diameter at breast height is expressed in centimetres and height is expressed in metres. The second index evaluated clones and cottonwoods according to the formula $\frac{DBH^2 \times ht \times survival}{100}$ where diameter at breast height and height are expressed in centimetres and metres, respectively, and survival is expressed in percent. Table 6 lists all clones and the cottonwood seedlings and cuttings in decreasing order of performance. It should be noted that there is little difference in the ranking between the two indices. For example, the 10 highest ranked clones and cottonwood seedlings according to Index 1 are also represented in the first 11 rankings according to Index 2. While these index figures represent no absolute values in volume or growth, they nevertheless show that there are important differences in survival and growth among clones, cottonwoods, and cottonwood seedlings and cuttings.

When the first-year results of Study 1 indicated significant differences in survival of cottonwood seedlings and cuttings, an additional experiment was established to determine the effects of mechanical and chemical weed control treatments on the survival and growth of cottonwood seedlings and cuttings. Three-year results of this study (Table 4) show that 2 + 0 seedlings survived significantly better than unrooted cuttings. The main reason for this was the poor rooting of the cuttings. While weed control treatments had no significant effect on the survival of the cuttings, seedling survival was reduced by annual application of 3.3 kg/ha of simazine. However, the good weed control obtained by this treatment improved seedling height. Rototilling for the first 3 years after planting produced the best seedling height but even rototilling during only the first year followed by simazine applications improved the 3-year height of the seedlings more than did chemical weed control alone. There was no significant difference in total height between cuttings and seedlings 3 years after planting. However, since the seedlings had an average height of 90 cm at time of planting, the 3-year height growth of the cuttings was superior to that of the seedlings.

When the preliminary results of studies 1 and 2 revealed that cottonwood seedlings survived and grew as well as or better than cottonwood cuttings or the cuttings of many hybrid poplar clones, a study was begun to determine and compare the survival and growth of different types of cottonwood planting stock. Bull and Putnam (1941) and Maisenhelder and McKnight (1968) reported that cottonwood seedlings survived better than cuttings when planted on low sites which were subject to flooding. However, few plantations have been established with seedlings. In the study reported here, failure to root resulted in significantly lower survival of unrooted cuttings and rooted cuttings with stems cut than of seedlings and rooted cuttings with stems not cut (Table 5). Differences in survival between cut stems of rooted cuttings and seedlings as well as the difference in survival between cut stems and unrooted cuttings cannot be explained. Decapitation of seedlings and root cuttings had no effect on survival or on total height 3 years after planting. Stems of cut seedlings and rooted cuttings therefore may be used to produce cuttings, whips or rooted cuttings for outplanting.

Table 6. Hybrid poplar cuttings and cottonwood seedlings and cuttings graded by (1) diameter and height and (2) diameter, height and survival.

Clones and cottonwood	Avg DBH[a] (cm)	Avg height[a] (m)	First[b] index	Rating	Survival[a] (%)	Second[c] index	Rating
D68	9.90	7.07	693	1	97	674	1
D38	8.60	7.80	577	2	92	530	3
DN38	8.77	7.43	571	3	83	476	5
DN19	9.03	6.83	557	4	97	542	2
Cot. seedlings	8.60	6.83	505	5	95	473	4
D70	8.53	6.90	502	6	70	349	10
DN22	8.23	7.33	496	7	89	440	6
DN30	8.07	6.87	447	8	97	435	7
D52	7.80	7.23	439	9	95	416	8
DN2	7.53	7.17	407	10	84	340	11
DN1	7.57	7.03	403	11	89	359	9
DTac1	7.63	6.67	388	12	86	335	12
I-65A	7.67	6.37	375	13	83	312	15
DN10	7.20	7.20	373	14	86	320	13
I-45/51	7.23	7.07	370	15	72	267	18
DN16	7.40	6.43	352	16	89	313	14
DN17	6.80	6.80	314	17	95	297	16
I-214	6.87	6.57	310	18	94	292	17
DN23	6.90	6.07	289	19	83	240	21
DN31	6.80	6.13	283	20	92	259	19
DN21	6.63	6.30	277	21	92	253	20
DN20	6.83	5.83	272	22	72	196	22
Cot. cuttings	6.47	6.23	261	23	50	130	26
DJac14	6.53	5.67	242	24	75	180	23
C147	5.83	5.37	200	25	80	160	24
DN5	5.80	5.77	194	26	78	150	25
D37	5.47	5.47	164	27	49	80	28
DN13	5.33	5.53	157	28	80	126	27

[a] Avg of 36 trees of treatments 1 to 3

[b] First index = $DBH^2 \times height$

[c] Second index = $\frac{DBH^2 \times height \times survival}{100}$

SUMMARY AND CONCLUSIONS

The results of these experiments show that simazine inhibits the rooting of cuttings of cottonwood and many hybrid poplar clones when applied at doses of more than 2.2 kg/ha shortly after planting. Once rooted, cuttings are more resistant and may tolerate applications of up to 6.6 kg/ha of active simazine. Cottonwood seedlings are also more resistant to simazine injury than are unrooted cuttings. Doses of more than 2.2 kg/ha of active simazine are generally required for effective weed control, but such doses may injure newly planted cuttings of cottonwood and many hybrid clones. It therefore appears advisable to apply simazine only in the second and later years after planting. Weed competition during the first year may be controlled by mechanical treatments, by the directed spray of glyphosate, or by the application of new herbicides after they have been proven not to harm the newly planted poplar cuttings.

Height and diameter, 5 years after planting, varied widely between individual hybrid poplar clones, between clones and cottonwoods and between cottonwood seedlings and cuttings. To obtain the highest possible yield from a given site it is therefore imperative to plant only clones which have grown well on similar sites.

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APPENDIX

APPENDIX

Origin of clones used in Study 1

Origin	Labelled
P. x *euramericana* cv. "Allenstein"	DN1
P. x *euramericana* cv. "Baden 431"	DN2
P. x *euramericana* cv. "Gelrica"	DN5
P. x *euramericana* cv. "Robusta, Germany"	DN10
P. x *euramericana* cv. "Regenerata Batard d'Hauterive"	DN16
P. x *euramericana* cv. "Robusta, France"	DN17
P. x *euramericana* cv. "tardif de Champagne"	DN18
P. x *euramericana* (Dode) Guinier	I-45/51
P. x *euramericana* cl. "Blanc de Potou", France	DN19
P. x *euramericana* cv. "I-61/59"	DN20
P. x *euramericana* cv. "Jacometti 78B"	DN21
P. x *euramericana* cv. "I-262"	DN22
P. x *euramericana* cv. I-106/56"	DN23
P. x *euramericana* cl. "Canada Blanc", Frande	DN30
P. x *euramericana* cv. "Negrito de Granada"	DN31
P. x *euramericana* cv. "NE-238", Schreiner	DN38
P. deltoides cl. D37, Wentworth, Ontario	DN37
P. deltoides cl. D38, Belleville, Ontario	DN38
P. deltoides cl. F10, Manitoba	D52
P. deltoides cl. 44, Indiana, U.S.A.	D68
P. deltoides cl. 138, Illinois, U.S.A.	D70
P. deltoides cl. "NE-32", Schreiner	DTac1
P. deltoides D37 x *Jackii* 1, cl. "DJac14", Maple, Ontario	DJac14
P. x *euramericana* cl. "I-214", Italy	I-214
P. x *euramericana* cv. "I-65A"	I-65A
P. x *canescens* (Ait.) Sm. cl. Ingolstadt 9b, W. Germany	C147