SOWING AND PLANTING SHAGBARK AND BITTERNUT HICKORIES ON FORMER FARMLAND IN SOUTHERN ONTARIO

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FORESTRY CANADA

ONTARIO REGION

GREAT LAKES FORESTRY CENTRE

1990

INFORMATION REPORT 0-X-403

Catalogue No. Fo 46-14/403E
ISBN: 0-662-16813-5
ISSN: 0832-7122

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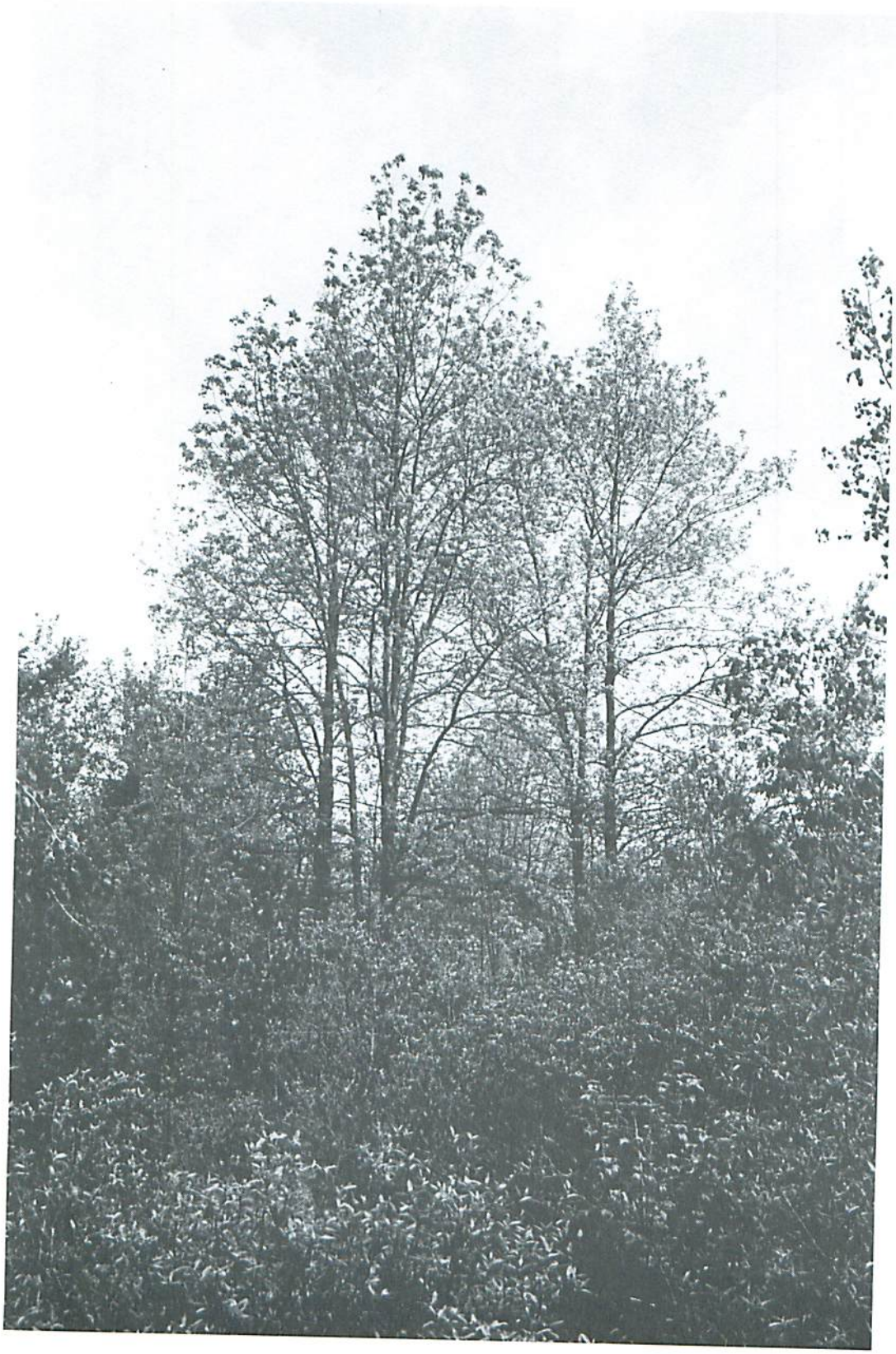

Frontispiece: A group of shagbark hickories in a natural woodlot.

von Althen, F.W. 1990. Sowing and planting shagbark and bitternut hickories on former farmland in southern Ontario. For. Can., Ontario Region, Sault Ste. Marie, Ont. Inf. Rep. O-X-403, 11 p.

ABSTRACT

Shagbark (*Carya ovata* [Mill.] K. Koch) and bitternut (*C. cordiformis* [Wang.] K. Koch) hickories were sown or planted in former fields near Parkhill, Middlesex County, Ontario. Growth rates and survival were evaluated after five years. Sowing of nuts was least successful because of low germination and slow growth. Raising shagbark hickory in containers presented no problems but survival of the outplanted seedlings was poor and height increments were low. Root pruning and age of bareroot seedlings had little effect on seedling survival and growth. Planting seedlings in alternate rows with autumn olive (*Elaeagnus umbellata* Thunb.) failed to improve the survival of shagbark hickory and did not affect height increment of either hickory. Until improved afforestation techniques are developed, sowing of nuts or planting of shagbark or bitternut hickory seedlings is not recommended.

RÉSUMÉ

Des caryers ovales (*Carya ovata* [Mill.] K. Koch) et des caryers cordiformes (*C. cordiformis* [Wang.] K. Koch) ont été semés ou plantés dans d'anciens champs près de Parkhill, dans la circonscription de Middlesex, en Ontario. Après cinq ans, on a évalué leur vitesse de croissance et leur survie. On a constaté que l'ensemencement a donné les moins bons résultats, la germination étant médiocre et la croissance lente. La production de semis de caryer ovale en récipients n'a pas posé de difficultés, mais la survie des plants après la transplantation a été médiocre, et leur accroissement en hauteur, faible. L'élagage des racines et l'âge des plants à racines nues ont peu influé sur la survie et la croissance. La plantation des rangs de caryers en alternance avec des rangs de chalefs en ombelles (*Elaeagnus umbellata* Thunb.) n'a pas amélioré la survie des caryers ovales et n'a eu aucun effet sur l'accroissement en hauteur de l'un ou l'autre caryer. Tant que de meilleures techniques de reboisement n'auront pas été mises au point, la création de peuplements de ces deux caryers, soit par ensemencement, soit par plantation, n'est pas recommandée.

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INTRODUCTION

Six species of hickory occur naturally in southern Ontario. Of these, shagbark (*Carya ovata* [Mill.] K. Koch) and bitternut (*C. cordiformis* [Wang.] K. Koch) are fairly common, while the other species are relatively rare and are confined to the most southerly parts of the Deciduous Forest Region (Hosie 1979). In the past, little interest in the artificial regeneration of hickories was shown by land managers. Lately, however, such interest has been growing because: (1) hickory wood is one of the toughest, hardest and strongest of Canadian hardwoods and is unequalled for use in sporting goods and tool handles, (2) the nuts of shagbark hickory are edible and, together with those of bitternut hickory, are important sources of food for wildlife, and (3) both species have potential in amenity planting and as replacements for white elm (*Ulmus americana* L.) in fencerows. Experiments were established in southern Ontario in 1980 to develop techniques for successful artificial regeneration of shagbark and bitternut hickories. This report presents the five-year results.

METHODS

Three studies were carried out in adjacent fields near Parkhill, Middlesex County, Ontario. The soil was an imperfectly drained silt loam 60 to 80 cm deep over silty sand (Anon. 1931). The pH of the plow layer was 7.0 and the organic matter content was 2.4%. All seed was collected locally, and nuts were stratified over winter in moist sand at 2°C. Bare-root stock was grown in the provincial nursery at St. Williams. Planting stock characteristics are given in Table 1.

Table 1. Initial morphological characteristics of planting stock used in these studies.

Species	Age class	Height (cm)			Root-collar diameter (mm)		
		Study 1	Study 2	Study 3	Study 1	Study 2	Study 3
Shagbark	containerized	-	12	-	-	2.5	-
Shagbark	2+0	19	19	15	4.5	4.5	4.0
Shagbark	3+0	-	27	-	-	6.5	-
Shagbark	4+0	28	-	-	8.5	-	-
Bitternut	2+0	-	-	26	-	-	4.0

Study 1

On 23 April 1980, after plowing and disking in the previous autumn, shagbark hickory seedlings, root-pruned to 20 cm, were machine planted and stratified shagbark and bitternut nuts were sown by hand at depths of 7 cm. Spacing was 3 m between rows and 1.5 m within rows. The study was laid out in a randomized block arrangement, with 20 seedlings or seed spots in each of eight treatments replicated six times.

Treatments consisted of:

1. planting 2+0 shagbark seedlings
2. planting 4+0 shagbark seedlings
3-5. sowing one, two or three shagbark nuts, respectively, per spot
6-8. sowing one, two or three bitternut nuts, respectively, per spot.

After germination, 2.2 kg/ha a.i. (active ingredient) of simazine were broadcast over the total area at the end of May 1980 and 4.4 kg/ha a.i. of simazine were broadcast annually in early April from 1981 to 1984. In July 1984 2.0 kg/ha a.i. of glyphosate were sprayed between the trees. Trees were pruned in 1982 and 1984 to remove forks and lower branches.

Study 2

On 2 May 1981, after plowing and disking in the previous autumn, 2+0 and 3+0 shagbark hickory seedlings were machine planted and shagbark nuts were sown 7 cm deep. Containerized seedlings were planted with a spade on 10 June 1981. These seedlings had been grown in a greenhouse by sowing pregerminated nuts on 23 March 1981 in open-ended tarpaper tubes 5 cm in diameter and 20 cm high filled with a growing medium of equal parts of peat and vermiculite. The medium was amended with lime to increase the pH of the peat to 6.2 and with 1 kg/m^3 of monosuper-phosphate (0-20-0), 0.4 kg/m^3 of calcium nitrate (15-0-0) and 0.4 kg/m^3 of potassium nitrate (13-0-44). The containers were stored in plastic boxes with walls 10 cm high. The seedlings were grown under an extended photoperiod of 16 hr and a temperature of approximately 18^0 (night) and 26^{0}C (day). After eight weeks the seedlings were transferred to a cold compartment for three weeks of conditioning. Spacing of seedlings and seed spots was 3 m between rows and 1.5 m within rows. The study was laid out in a randomized block arrangement with 20 seedlings or seed spots in each of six treatments replicated 12 times. Treatments consisted of:

1. sowing two nuts per seed spot
2. planting containerized seedlings
3. planting 2+0 seedlings with roots pruned to 20 cm
4. planting 2+0 seedlings with roots not pruned

5. planting 3+0 seedlings with roots pruned to 20 cm
6. planting 3+0 seedlings with roots not pruned.

On 4 May 1981 simazine was sprayed at a rate of 2.2 kg/ha a.i. in bands 1.5 m wide over all rows planted five days previously with bare-root seedlings. On 8 June 1981 glyphosate was sprayed at a rate of 2.0 kg/ha a.i. in bands 1.5 m wide over all rows to be planted with containerized seedlings. On 12 June 1981 simazine was sprayed at a rate of 2.2 kg/ha a.i. in bands 1.5 m wide over the rows planted with containerized seedlings and those sown on 2 May. In April 1982 and 1983 simazine was broadcast over the total experimental area at a rate of 4.4 kg/ha a.i. In July 1982 glyphosate was sprayed at a rate of 2.0 kg/ha a.i. between all trees. Trees were pruned in July 1983 and 1985 to remove forks and lower branches.

Study 3

On 26 April 1982, after plowing and disking in the previous autumn, 2+0 shagbark and bitternut hickory seedlings, root-pruned to 20 cm, and 2+0 autumn olive (*Elaeagnus umbellata* Thunb.) seedlings were machine planted at a spacing of 2 m between rows and 1.5 m within rows. The study was laid out in a randomized block arrangement with a total of 464 shagbark hickory, 464 bitternut hickory and 336 autumn olive seedlings planted in three treatments replicated three times.

Treatments consisted of:

1. alternate rows of shagbark and bitternut hickories
2. alternate rows of shagbark hickory and autumn olive
3. alternate rows of bitternut hickory and autumn olive.

Shortly after planting and in April 1983 and 1984 simazine was broadcast at a rate of 4.4 kg/ha a.i. over the total plantation area. In early July 1984 glyphosate was sprayed at a rate of 2.0 kg/ha a.i. between all trees and shrubs. Trees were pruned in July 1984 and 1986 to remove forks and lower branches.

DATA COLLECTION AND ANALYSIS

In each of the three studies, survival and height were recorded shortly after planting and in the autumn of years 1, 3 and 5. The five-year data were subjected to analyses of variance and Tukey's multiple range tests. Each July composition of the herbaceous vegetation was recorded and the percentage of bare ground was ocularly estimated.

RESULTS

Study 1

Sowing three nuts per seed spot or planting nursery-grown seedlings resulted in significantly higher stocking of shagbark hickory than sowing one or two nuts per spot (Table 2). Height increment of sown and planted shagbark seedlings varied widely within treatments but was significantly different only between two nuts sown per seed spot and 4+0 seedlings. In comparison with survival of shagbark, fifth-year survival of bitternut was so low that statistical analysis was not warranted.

Table 2. Five-year survival and height increment of seeded and planted hickories (Study 1).

Treatment	Survival		Height increment (cm)	
	Shagbark	Bitternut	Shagbark	Bitternut
	% of planting spots stocked			
One nut per spot	14a	2	19ab	61
Two nuts per spot	26a	3	16a	89
Three nuts per spot	47b	3	21ab	70
2+0 seedlings	72c	-	29ab	-
4+0 seedlings	62bc	-	38b	-

Note: Means followed by different letters differ significantly ($p < 0.05$).

The most common weed species during the first year after planting were: common ragweed (*Ambrosia artemisiifolia* L.), common milkweed (*Asclepias syriaca* L.), goldenrod (*Solidago* spp.) and quackgrass (*Agropyron repens* [L.] Beauv.). During the next four years the composition of the weed cover changed from predominantly ragweed, milkweed and quackgrass to goldenrod and tall fescue (*Festuca arundinaceae* Schreb.). Table 3 lists the chemical treatments applied and shows their effectiveness in controlling the herbaceous vegetation.

Study 2

Survival and height increment of bare-root seedlings were significantly greater than those of sown and containerized seedlings (Table 4). However, there was no clear difference in survival or height increment between age classes or root-pruning treatment of bare-root seedlings. Growth of 3+0 shagbark seedlings after eight years is shown in Figure 1. Over all, the best treatment was planting root-pruned 2+0 seedlings.

Table 3. Chemical weed control (Study 1).

Date of application	Herbicide applied	Dosage (kg/ha a.i.)	Date of assessment	Bare soil (%)
27 May 1980	simazine	2.2	25 July 1980	30
13 April 1981	"	4.4	27 July 1981	40
17 April 1982	"	4.4	30 July 1982	40
15 April 1982	"	4.4	26 July 1983	40
11 April 1984	"	4.4	27 July 1984	50
03 July 1984	glyphosate	2.0	27 July 1984	50

Table 4. Five-year survival and height increment of sown and planted shagbark hickory (Study 2).

Treatment	Survival (% of planting spots stocked)	Height increment (cm)
Two nuts sown per spot	1a	10a
Containerized seedlings	19b	20a
2+0 seedlings, roots pruned to 20 cm	82d	63c
2+0 seedlings, roots unpruned	67c	68c
3+0 seedlings, roots pruned to 20 cm	80cd	46b
3+0 seedlings, roots unpruned	85d	53bc

Note: Means followed by different letters differ significantly ($p<0.05$).

The composition of the competing vegetation was very similar to that of Study 1. Table 5 lists the chemical weed control treatments applied by date, dosage and stock type treated and shows treatment effectiveness by year of application.

Study 3

Five years after planting, mean heights of autumn olive, shagbark hickory and bitternut hickory were 292, 140 and 174 cm, respectively. Interplanting with autumn olive had no effect on survival or height increment of shagbark hickory (Table 6). However, interplanting increased the survival but decreased the height increment of bitternut hickory. Examples of the growth obtained are presented in Figures 2 (bitternut and shagbark hickories) and 3 (shagbark hickory and autumn olive).

Figure 1. Shagbark hickory, 11 years old from seed, planted as 3+0 bare-root seedlings.

Table 5. Chemical weed control (Study 2).

Stock planted (planting date)	Date of herbicide application	Herbicide applied	Dosage (kg/ha a.i.)	Date of assessment	Bare soil (%)
Bare-root seedlings (02 May 1981)	04 May 1981	simazine	2.2	27 July 1981	30
Nuts sown (02 May 1981)	12 June 1981	simazine	2.2	27 July 1981	20
Containerized seedlings (10 June 1981)	08 June 1981 12 June 1981	glyphosate simazine	2.0 2.2	27 July 1981	60
All stock	17 April 1982 05 July 1982	simazine glyphosate	4.4 2.0	30 July 1982	70
All stock	15 April 1983	simazine	4.4	26 July 1983	50

Table 6. Five-year survival and height increment of shagbark and bitternut hickories planted in alternate rows and with autumn olive (Study 3).

Treatments	Survival (%)			Height increment (cm)		
	Shagbark	Bitternut	Olive	Shagbark	Bitternut	Olive
Shagbark and bitternut hickories planted in alternate rows	77a	69a	-	123x	185x	-
Shagbark hickory planted in alternate rows with autumn olive	76a	-	84a	130x	-	261x
Bitternut hickory planted in alternate rows with autumn olive	-	78b	83a	-	155y	255x

Note: Within species, means followed by different letters differ significantly ($p < 0.05$).

The herbaceous competition consisted mainly of Lamb's quarters (*Chenopodium album* L.), spiny annual sow thistle (*Sonchus asper* [L.] Hill), goldenrod and tall fescue. Table 7 lists the chemical treatments applied and shows their effectiveness in controlling the herbaceous competition. During the third growing season autumn olive started to suppress the herbaceous vegetation by shading. In years 4 and 5 competition control in the autumn olive plots was 70 and 90%, respectively, while in plots without autumn olive competition, control was 30% in year 4 and 10% in year 5.

Table 7. Chemical weed control (Study 3).

Date of application	Herbicide applied	Dosage (kg/ha a.i.)	Date of assessment	Bare soil (%)
28 April 1982	simazine	4.4	30 July 1982	40
16 April 1983	"	4.4	25 July 1983	40
11 April 1984	"	4.4	27 July 1984	70
08 July 1984	glyphosate	2.0	27 July 1984	50
-	-		26 July 1985	30
-	-		25 July 1986	10

Figure 2. Alternate rows of bitternut (left) and shagbark (right) hickories seven years after planting.

Figure 3. Shagbark hickory planted in alternate rows with autumn olive, seven years after planting.

DISCUSSION

Shagbark and bitternut hickories have been planted sparingly and little is known about their suitability and potential for the afforestation of abandoned farmland. Both species are difficult to grow in the nursery because top growth is slow until a strong tap root has grown to a depth of 30 cm or more. The bare-root seedlings planted in these studies were the first hickory seedlings grown in Ontario's provincial nurseries. The roots were not pruned in the seedbeds and had lengths of 30 to 60 cm. Approximately 50% of the roots were damaged during lifting. The seedlings planted in studies 1 and 3 were root pruned to 20 cm to facilitate machine planting as well as to remove damaged sections, which were generally located near the root tip. Seedlings with roots damaged within 20 cm of the root collar were discarded. In Study 2 all seedlings were sorted according to root length. Those with healthy roots not exceeding 40 cm in length were planted in treatments 4 and 6 while the remaining seedlings were root pruned and planted in treatments 3 and 5.

In this study, raising containerized seedlings presented no problems, but the seedlings were fragile and had to be handled with care during shipping and planting. Seeding of nuts proved to be the least successful measure because of low germination and slow growth. Most seedlings perished because they were unable to compete with herbs and grasses.

The most serious threat to successful seedling establishment was competition from herbaceous plants and grasses. All experimental sites were free of competition at the time of planting. In Study 1, application of simazine during the first year was delayed until the end of May to allow the sown nuts to germinate. Then only 2.2 kg/ha a.i. of simazine were applied to avoid possible damage by herbicide to the newly germinated seedlings. This treatment proved ineffective in preventing the establishment of dense herbaceous competition. Applications of 4.4 kg/ha a.i. of simazine in April of the next three years prevented further intensification of competition but did not eradicate the established weeds. One application of 2.0 kg/ha a.i. of glyphosate in early July of the fifth growing season provided 50% competition control, but tall fescue and goldenrod were not eradicated. The application of glyphosate with backpack sprayers was very time consuming because most seedlings were so small that special attention was needed to avoid overspraying or damage from herbicide drift. The seedlings were not shielded, but the nozzle of the sprayer was held low. Spraying was carried out in the morning or late afternoon when air movement was minimal. With the exception of a few seedlings that were oversprayed by mistake because they were hidden among the weeds, no trees were seriously damaged.

In Study 2, band application of 2.2 kg/ha a.i. of simazine on 4 May 1981 provided 30% competition control during the first year, while the same dosage applied on 12 June provided only 20% control. This difference is believed to be due mainly to the fact that weeds of most

species had germinated and were actively growing on 12 June. Because simazine is a pregermination herbicide it was less effective in controlling established weeds (von Althen 1979). Band application of 2 kg/ha a.i. of glyphosate on 8 June 1981 followed by band application of 2.2 kg/ha a.i. of simazine four days later provided 60% competition control. Broadcast application of 4.4 kg/ha a.i. of simazine in April of the second year, followed by an application of 2.0 kg/ha a.i. of glyphosate at the beginning of July of the same year, eradicated most ragweed and quackgrass and seriously retarded the growth of goldenrod and milkweed. Broadcast application of 4.4 kg/ha a.i. of simazine in April of the third year provided 50% control.

In Study 3, broadcast application of 4.4 kg/ha a.i. of simazine shortly after planting and in April of the second year provided 40% control of mainly Lamb's quarters, sow thistle and tall fescue. Application of 2.0 kg/ha a.i. of glyphosate in early July of the third year eradicated most of the Lamb's quarters and sow thistle, but not tall fescue. Since Lamb's quarters and sow thistle were as tall as or taller than most hickory seedlings by early July, herbicide application was difficult and time consuming. It would have been much easier to apply glyphosate in late May or early June when the weeds were still smaller than the tree seedlings. Application of glyphosate in late spring will not control competition as effectively as a later application, because regrowth or new growth is generally extensive during the summer. Good control may, therefore, require a second application of glyphosate in late July, but the danger of damage to tree seedlings by herbicides is much reduced.

The interplanted autumn olive started to provide competition control by shading during the third year. In the fifth year competition control was 90%.

Interplanting shagbark or bitternut hickories with autumn olive had no effect on the height increment of shagbark hickory and a negative effect on bitternut hickory. These results are rather surprising because interplanting of autumn olive with black walnut seedlings has always increased walnut growth (Funk et al. 1979, Ponder 1983, Friedrich and Dawson 1984). Although spacing between rows in our study was only 2 m and some hickory seedlings were partially shaded by the taller autumn olive, the majority of hickories appeared to have ample growing space.

During the first years after planting the main benefit derived from autumn olive interplanting is competition control. The long-term benefit is improved nitrogen nutrition brought about by the nitrogen-fixing ability of autumn olive (Friedrich and Dawson 1984). In the present study, slow growth of hickories during the first five years after planting probably prevented the trees from taking advantage of the increased supply of soil nitrogen. It remains to be seen if and when the hickories will respond to the benefits provided from interplanting with autumn olive.

CONCLUSIONS

The results of these studies show that shagbark and bitternut hickories are difficult to establish in open-field plantations. Sowing of nuts was the least successful method of afforestation studied because germination was low and height increment was slow. Raising containerized seedlings in the greenhouse presented no problems but survival of the outplanted seedlings was poor and height growth was slow. Hickory seedlings are difficult to grow in the nursery because top growth is slow while root growth is extensive. Root pruning and age of planting stock had little effect on seedling survival and height growth. Planting hickories in alternate rows with autumn olive failed to improve the survival of shagbark hickory or the height increment of either species.

Without further study of the silvics of shagbark and bitternut hickories and without the development of techniques leading to substantial improvement in their survival and early growth, afforestation of former farmland with these species is not recommended.

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