EARLY HEIGHT GROWTH INCREASED IN BLACK WALNUT-SILVER MAPLE INTERMIXTURES[1]

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Abstract.--Black walnut was planted in alternate rows with silver maple, autumn olive, black locust or white pine in two plantations in southwestern Ontario. Best competition control and growth of black walnut occurred in silver maple-black walnut intermixtures at spacings of 2 m between rows and 1.5 m within rows. This mixture provided 90% competition control in the 4th year after planting and significantly increased 5-year height increment of black walnut. Silver maple intermixtures, however, reduced levels of foliar nitrogen in walnut in comparison with those in autumn olive intermixtures.

Key words: black walnut, silver maple, autumn olive, white ash, black locust, interplanting, competition control, height increment, foliar nitrogen content.

INTRODUCTION

High timber value and acceptable growth on former farmland have made black walnut (*Juglans nigra* L.) a preferred species for afforestation in southwestern Ontario. However, the success of black walnut plantations has been variable because site requirements were not met, herbaceous competition was not controlled or trees were not sheltered from wind damage during the early years after planting. To improve plantation success, black walnut has been planted in mixture with other tree species. Interplanting with nitrogen (N)-fixing species such as black locust (*Robinia pseudoacacia* L.), European alder (*Alnus glutinosa* L. [Gaertn.]) or autumn olive (*Elaeagnus umbellata* Thunb.) has increased walnut growth through increased soil N, competition control and protection from wind (Schlesinger and Williams 1984). However, little research has been done with intermixtures of non-nitrogen fixing hardwood species. Interplanting with white pine (*Pinus strobus* L.) has had limited success (von Althen and Nolan 1988). To determine the potential of silver maple (*Acer saccharinum* L.) as a nurse species for black walnut, two studies were carried out in southwestern Ontario. This report presents the 5-year results.

METHOD

Two studies were established on former agricultural land near Parkhill, in Ontario's Middlesex County. Study 1 was a non-replicated pilot study that consisted of four plots of 0.33 ha each. The soil was a poorly drained Parkhill loam (Richards and Morwick 1952) 70 to 80 cm deep with a pH and organic matter content of the plow layer of 7.0 and 2.8%, respectively. The entire experimental area was plowed and disked in the autumn of 1981 and seedlings were machine-planted in April 1982 at a spacing of 3 m between rows and 1.5 m within rows. In the first plot, 693 1+0 black walnut were planted in 11 rows of 63 seedlings each. In the other three plots, 315 1+0 black walnut were planted in five rows, each containing 63 seedlings. Each row of walnut was surrounded on either side by rows of 63 seedlings (i.e., six rows in all) of one of the following species: 2+0 silver maple, 2+0 black locust, or 3+0 white pine (one species per plot).

Shortly after planting, and in April of the next two years, 6.0 kg/ha of active simazine were broadcast over the entire plantation area. Forks and lower branches of the walnuts were pruned during the third and fifth summers after planting.

Study 2 was laid out in a randomized block design with three replications of each of five treatments. The soil was an imperfectly drained Perth loam (Richards and Morwick 1952) 60 to 70 cm deep with a pH and organic matter content of the plow layer of 6.8 and 2.6%, respectively. After the harvest of corn (*Zea mays* L.), the field was plowed in November 1982 and tree and shrub seedlings were machine planted in April 1983.

Treatments consisted of: 1) black walnut in nine rows at a 3-m spacing between rows; 2) seven rows of silver maple alternating with six rows of walnut, with a 2-m spacing between rows; 3) five rows of silver maple alternating with four rows of walnut, with a 3-m spacing between rows; 4) as in treatment 3, but with white ash (*Fraxinus americana* L.) instead of silver maple; and 5) as

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in treatment 3, but with autumn olive instead of silver maple.

The stock used in study 2 was 1+0 walnut; other species were 2+0 stock. Trees were planted 1.5 m apart within each 25-tree row.

Competition control consisted of broadcast application of 3 kg/ha of active simazine over the entire plantation area shortly after planting and 4 kg/ha in April of each of the next two years. Forks and lower branches of black walnut were pruned during the third and fifth summers after planting. In July 1987, branches and secondary stems of the silver maple planted between the black walnuts at a spacing of 2 m (treatment 2) were pruned in half of each plot to open a space of approximately 80 cm between the crowns of black walnut and silver maple.

DATA COLLECTION AND ANALYSIS

In both studies composition of the herbaceous vegetation was recorded each July and the intensity of competition was assessed by visual rating of the percentage of ground cover. Survival and total height of all planted tree and shrub species were recorded at the end of the first, third, and fifth growing seasons. The breast-height diameter (DBH) of walnuts planted in study 2 was also recorded at the end of the fifth growing season. Five composite foliage samples (two walnut leaves from each of five trees) were collected in each plot of study 2 in late July of the fifth growing season. All samples were analyzed for N content by the semi-micro Kjeldahl method.

The fifth year competition, survival, height, DBH and foliar N data from walnut in study 2 were subjected to analyses of variance and Tukey's test of significance.

RESULTS

In study 1, broadcast applications of 6.0 kg/ha of active simazine shortly after planting and in April of the next two years provided 70-90% competition control in all plots in the first three years but greatly reduced the survival of black locust and white pine and of black walnut interplanted with black locust (Table 1). Competition control in year five ranged from 20% in the black walnut-white pine mixture to 90% in the black walnut-silver maple interplanting. The most common weed species were tall fescue *(Festuca arundinaceae* Schreb.), quack grass *(Agropyron repens* [L.] Beaur.), goldenrod *(Solidago* spp.), common milkweed *(Asclepias syriaca* L.), spiny annual sow-thistle *(Sonchus asper* [L.] Hill) and Canada thistle *(Cirsium arvense* [L.] Scop). Height increment of black walnut in the pure plantation and in the black walnut-silver maple mixture was similar, and was greater than in the black walnut-black locust or black walnut-white pine mixtures (Table 1).

In study 2, broadcast applications of 3 kg/ha of active simazine shortly after planting and 4 kg/ha in April of the next two years provided 60% competition control during the first three years, and an additional 10 to 20% of natural control was provided by shade from the interplanted silver maple (Table 2). Competition control in year 5 ranged from 40% in the pure black walnut and the walnut-ash mixture to 95% in the walnut-maple mixture planted at a spacing of 2 x 1.5 m. The most common weed species were tall fescue, quack grass, goldenrod and Canada thistle.

Five-year survival and DBH of black walnut differed little among treatments, but height increment was significantly higher in the walnut-maple mixture planted at 2 x 1.5 m than in the pure walnut planting or the walnut-ash or walnut-

Table 1.--Competition control and five-year survival and height increment in a pure black walnut plantation and in intermixtures of either silver maple, black locust or white pine with black walnut (study 1).

Plantation mixture	Competition control in year		Survival		Height increment	
	4	5	Black walnut	Nurse species	Black walnut	Nurse species
	- - - (%) - - -		- - - (%) - - -		- - - (cm) - - -	
Pure black walnut	50	50	99	-	314	-
Black walnut - silver maple	80	90	100	100	324	521
Black walnut - black locust	60	60	80	63	289	520
Black walnut - white pine	30	20	97	33	272	94

Note: Studies were not replicated, so no statistical analyses were done.

Table 2.--Competition control, five-year survival and height increment, DBH and foliar nitrogen concentrations in a pure black walnut plantation and in intermixtures of either silver maple, white ash or autumn olive with black walnut (study 2).

Plantation mixture	Competition control in year		Survival		Height increment		DBH	Foliar nitrogen
	4	5	Black walnut	Nurse species	Black walnut	Nurse species	Black walnut	Black walnut
	- - (%) - -		- - - (%) - - -		- - - (cm) - - -		-(cm)-	(% dry weight)
Pure black walnut 3 x 1.5 m spacing	40	40a	82a	-	230a	-	2.8a	1.87ab
Black walnut - silver maple 2 x 1.5 m spacing	90	95c	83a	96a	323b	473a	2.9a	1.78a
Black walnut - silver maple 3 x 1.5 m spacing	80	90c	83a	98a	267ab	484a	2.8a	1.74a
Black walnut - white ash 3 x 1.5 m spacing	40	40a	86a	91	237a	339	2.9a	1.95ab
Black walnut - autumn olive 3 x 1.5 m spacing	50	60b	82a	91	230a	231	2.8a	2.07b

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

olive mixtures (Table 2). Results of the foliar analyses suggest a deficiency in N (as defined by Finn [1966] and von Althen [1985]) in all walnuts except those planted in mixture with autumn olive (Table 2). The N content of leaves of black walnut planted in mixture with autumn olive was significantly higher than that of walnuts planted in mixture with silver maple.

DISCUSSION

Black walnut is very demanding in its site requirements (Carmean 1966, Losche 1973) and is highly susceptible to the herbaceous competition that flourishes on good walnut sites during the early years after planting (Byrnes et al. 1973, von Althen 1985). Competition control has therefore become standard practice in walnut plantation establishment. However, annual weed control is expensive and becomes more difficult to apply as the trees grow larger. After the first two or three years, the established seedlings are expected to provide their own weed control through shading. However, black walnut has a relatively thin foliage and the shade cast is insufficient to retard the invasion of weed species after the artificial weed control treatments are discontinued, as shown by my data for the pure walnut plots.

Young black walnuts are also highly susceptible to mechanical damage by wind or rain. The long, tender shoots, with numerous, large compound leaves, are easily broken off in early summer before they are lignified (Schneider et al. 1968, Burke and Williams 1973).

To improve natural competition control and to provide greater protection against mechanical damage, black walnut has been planted in mixture with various nurse species. Interplanting black walnut with N-fixing tree and shrub species such as black locust, European alder or autumn olive has increased walnut growth through improved soil N supply and better competition control (Clark and Williams 1979, Ponder et al. 1980, Friedrich and Dawson 1984).

In Ontario, over 200 mixed plantations of black walnut and white pine have been established according to a prescription by Johnston (1979). The objectives of this prescription are fourfold: (1) to shade out the herbaceous vegetation, thereby increasing the available soil moisture and nutrients; (2) to deprive meadow voles (*Microtus pennsylvanicus* Ord.) of cover and food and prevent voles from girdling young walnut trees (Radvanyi 1974, 1975); (3) to decrease damaging winds, shade out the lower branches of the walnuts, and force walnut height growth; and (4) to stimulate juglone production as a built-in thinning mechanism 25 to 30 years after planting.

Some excellent plantations were established according to the Johnston (1979) prescription, but walnut growth was lower than expected in the majority of plantations (von Althen and Nolan 1988). Although many factors contributed to disappointing growth, competition control was identified as the most important. The main problem appears to be inadequate shading because of slow juvenile height increment of white pine. In the year of planting, height increment of black walnut generally does not exceed a few centimetres, but

beginning in year two, black walnut is capable of growing up to 1 m per year. In contrast, white pine has a much lower rate of juvenile height increment and generally requires 4-5 years to obtain a height of 1.5 m (Horton and Bedell 1960). If artificial competition control is discontinued after three years, the white pine are generally unable either to provide the competition control required to prevent invasion of weed species or to protect the walnuts from wind damage. This was confirmed by the results of study 1.

In the present paper, the potential of silver maple as a nurse species for black walnut was investigated because silver maple exhibits: (1) good growth on all walnut sites; (2) high juvenile growth rate; (3) dense foliage that provides shade for excellent competition control; (4) relatively high tolerance of simazine (von Althen 1979); (5) ease of culture in the nursery; and (6) minimal tendency to spread. Its disadvantages are poor stem form and faster juvenile growth than black walnut.

In study 1, high mortality of black locust and white pine was caused by simazine poisoning (Table 1). Although both species normally tolerate dosages of 6 kg/ha of active simazine (von Althen 1979), a heavy rain one day after application washed simazine into a slight depression of the near-level field and thereby increased the simazine concentrations in this area. This was made evident by the near absence of ground vegetation in the depression during the first summer and the greater-than-normal growth of competition in the remainder of the plot. The low survival of black walnut interplanted with black locust has not been explained. The superior height increment of black walnut planted in mixture with silver maple is believed to be the result of excellent weed control in combination with the forcing of walnut height growth by strong competition for light from the interplanted maples. The slow growth of black walnut in mixture with white pine is believed to be the result of inadequate competition control and the failure of the white pine to force walnut height growth (Table 1).

After discontinuation of the chemical competition control, the pure walnut, the walnut-ash and the walnut-olive mixtures in study 2 were invaded by broadleaved weeds and grasses during the fourth year; in contrast, shade from the tall silver maples maintained or improved competition control. Since black walnut grows poorly in the presence of herbaceous competition, the significant growth improvement of black walnut interplanted with silver maple is assumed to have been largely the result of competition control. However, walnut height increment was no doubt also influenced by competition for light from the interplanted maples. This competition forced walnut height growth, and reduced the size of branches on the lower bole of the walnuts.

After 5 years silver maple was 150 to 200 cm taller than walnut and had started to shade the walnut interplanted at the 2 x 1.5 m spacing (treatment 2). Removal of branches and secondary stems of silver maple provided added growing space but it remains to be seen if walnut will be able to maintain its height in relation to that of silver maple. If silver maple increases its height advantage further, it may be necessary to lop the tops of the trees.

Previous studies have shown that rapidly growing walnut trees have a foliar N content of over 3% (Finn 1966, Maeglin et al. 1977, Pope et al. 1982, von Althen 1985). An N content of between 2.5 and 3% indicates adequate supply of this nutrient, between 2 and 2.5% a possible N deficiency, and below 2% a definite nitrogen deficiency and probably serious stress. The significant difference between levels of foliar N of walnuts planted in mixture with autumn olive and silver maple suggests a soil N enrichment by autumn olive and an impoverishment by silver maple.

The N-fixing ability of autumn olive and its beneficial effect on walnut growth are well documented (Funk et al. 1979; Ponder 1980, 1983; Friedrich and Dawson 1984). The spreading form of autumn olive also provides soil shading and competition control. In study 2, competition control by autumn olive was inferior to that of silver maple but better than that provided by either pure walnut or the walnut-ash mixture (Table 2). Because total heights of black walnut and autumn olive were nearly equal, the olive provided adequate protection against wind damage. The greatest disadvantage of planting autumn olive is its spread to adjacent areas. Planting of autumn olive is therefore prohibited in some regions.

Interplanting black walnut with white ash is appealing because white ash is a valuable species and an excellent substitute for walnuts that fail to produce good-quality stems. At the end of the fifth growing season, white ash was 1 m taller than black walnut. Consequently, the walnuts were well protected from damage by wind but the characteristically long, narrow crowns of the young white ash provided only limited shade and, therefore, relatively poor competition control.

SUMMARY AND CONCLUSIONS

Planting black walnut in alternate rows with silver maple provided excellent natural competition control and protection from damage by wind. Interplanting black walnut and silver maple at a spacing of 2 m between rows and 1.5 m within rows significantly increased the 5-year height increment of black walnut and reduced the size of branches on the lower bole. However, because the walnuts were threatened with suppression, the interplanted silver maples had to be pruned severely in the fifth year after planting. Interplanting black walnut with autumn olive significantly increased foliar N content over that of walnut interplanted with silver maple. A longer period of observation is required to determine the potential of silver maple as a nurse species for black walnut.

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