Performance of Hardwoods Planted With Autumn Olive After Removing Prior Cover

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ABSTRACT.—White ash, white oak, and black walnut were planted with and without autumn olive on a site previously occupied by a 10-year-old stand of autumn olive. Seven years later, height, diameter, and foliar nitrogen were significantly greater in plots with autumn olive than in plots without autumn olive. White oak in plots previously occupied by autumn olive were larger in diameter but shorter than white oak in plots previously inhabited by shrubs and scattered hardwoods. Prior cover of autumn olive apparently did not increase growth more than prior cover of shrubs and scattered hardwoods.

Plantings of hardwoods on old fields rarely succeed. Research suggests that growing conditions for many commercial hardwoods are improved when brushy vegetation is allowed to inhabit old fields for several years before the desired tree species are planted (Carmean *et al.* 1976). Among the more easily established woody plants are those capable of fixing nitrogen such as black locust (*Robinia pseudoacacia* L.), alder (*Alnus* spp.), and autumn olive (*Elaeagnus umbellata* Thunb.). Finn (1953) found that yellow poplar (*Liriodendron tulipifera* L.), sweetgum (*Liquidambar styraciflua* L.), black walnut(*Juglans nigra* L.), and red oak (*Quercus rubra* L.) grew rapidly and had high foliar nitrogen levels when grown in association with black locust. Similar results have been reported by Funk *et al.* (1979) for black walnut mixed with autumn olive and for white ash (*Fraxinus americana* L.) planted with European alder (*Alnus glutinosa* L.[Gaertn.] (Plass 1977). In the absence of the nitrogen-fixing species, these planted hardwoods grew poorly in both studies.

Soil nitrogen has also been found to be greater in mixed forest stands containing nitrogen-fixing species (Hansen and Dawson 1982, Ike and Stone 1958). Interplantings of walnut with black locust and autumn olive had the highest total soil nitrogen concentrations in the top 30 cm of soil, followed by European alder, lespedeza clover (*Lespedeza striata* [Thunb.] Hook & Arn.), and control plots (Friedrich and Dawson 1984).

Soil nitrogen can be extremely variable and ephemeral. It is not known how long the accumulated nitrogen remains in the soil after nitrogen-fixing plants no longer occupy the site. The main objective of this study was to compare the performance of white oak (*Q. alba* L.) planted with and without autumn olive both on an old field previously occupied by autumn olive and on a field with other prior cover. The growth of planted black walnut and white ash with and without autumn olive after the initial stand of autumn olive was removed is also described.

METHODS AND MATERIALS

Site and Site Preparation

The study was established on two bottomland fields on the Kaskaskia Experimental Forest in Hardin County, Illinois; one had been planted to black walnut (Goolsby tract) and the other

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(Rendleman tract) had been planted to black walnut and autumn olive. Both 10-year-old plantings failed because of the poor survival of the black walnut. The few trees that remained were poorly formed and had grown very little. Walnut trees at the Rendleman tract were overtopped by autumn olive for a number of years. The shade provided by the autumn olive prevented establishment and survival of most woody and herbaceous volunteer plants there. Grasses, shrubs, and scattered naturally seeded hardwoods, including cottonwood (*Populus* spp.), sycamore (*Platanus occidentalis* L.), and sweetgum (*Liquidambar styraciflua* L.), made up the ground cover at the Goolsby tract.

Soils on the Goolsby and Rendleman tract are primarily of the Wakeland series (fine-silty, mixed, mesic, Aeric Fluvaquents). Most of the Goolsby tract has slopes near 3 to 5%. The silt clay loam soil there is moderately well drained to somewhat poorly drained and 1.5 to 2.2 m deep. Soils on the Rendleman tract have depths similar to those on the Goolsby tract and are nearly level and somewhat poorly drained.

To prepare the sites, existing trees and autumn olives were removed using a small tractor with a bulldozer. The overall disturbance caused by the clearing was slight. Many of the branches and roots were removed from the site by hand. The sites were disked several times after clearing. All site preparation was done in the summer and fall of 1982.

Study Design and Measurements

One-year-old nursery-grown seedlings were planted on both tracts in the spring of 1983. Rows were 3.1 m apart, and seedlings in the rows were 2.4 m apart. In the mixed treatment, autumn olive seedlings were interplanted within the rows at a spacing of 1.2 m from tree seedlings. Each tree seedling in the mixture was flanked by two autumn olives. White ash, white oak, and black walnut were planted with and without autumn olive at the Rendleman tract, and white oak only was planted with and without autumn olive at the Goolsby tract. The study was laid out as a completely randomized design. Each treatment was replicated 4 times. Each replicate contained 60 tree seedlings. Dead and missing seedlings were replaced in the spring of 1984. Autumn olive outgrew many of the oaks, and it was cut to near ground level in 1985 at the Goolsby tract and to a height of 1 m in 1988 in oak plots at both sites.

Simazine and glyphosate were applied in a 0.5-m band, on both sides of the seedling rows annually from 1983 through 1986. Simazine was applied at 4.4 kg/ha, usually in early March, and glyphosate (5.4 l/ha) was applied before the first of May.

Height and diameter (30.5 cm above the ground) have been recorded on 32 interior trees/replicate each fall since 1983. Leaf and soil (0 to 15.2 cm) samples were collected in mid-June of 1989 for nutrient analyses. Data were subjected to an analysis of variance; differences were considered statistically significant at the 0.05 level according to Duncan's multiple range test.

RESULTS

Survival

Survival declined at both sites between the years of 1985 and 1989, with the greatest decline at the Goolsby tract (Table 1). Plots with autumn olive at the Goolsby tract had 25% fewer trees in 1989 than 4 years earlier, while plots without autumn olive declined by only 12%.

Table 1.—Percent survival of hardwoods planted with and without autumn olive at two locations

	Rendleman tract						Goolsby tract	
	White ash		Black walnut		White oak		White oak	
Year	Without	With	Without	With	Without	With	Without	With
1985	96	100	100	100	98	93	91	100
1989	94	98	89	91	96	89	79	75

Over the same period, survival of oaks on the Rendleman tract declined by only 4 and 2% with and without autumn olive, respectively. The survival of white ash and black walnut was only slightly higher with autumn olive than without.

Height and Diameter

Seven years after outplanting, trees planted with autumn olive were taller and larger in diameter than trees planted in plots without autumn olive (Tables 2 and 3). Height enhancement attributed to autumn olive was not apparent in all trees in the same year. Differences in black walnut height began to be noticeable by year 5, but differences were not significant (a = 0.05) until year six. Height differences between treatments in white ash were not apparent until year six and were significant by year seven. Overall, white ash and black walnut planted with autumn olive were 0.62 and 0.78 m taller, respectively, than trees planted without autumn olive. Trees planted with autumn olive were also larger in diameter than trees planted without autumn olive; however, differences between the two treatments were not significant until year seven for white ash and year six for black walnut.

Table 2.—Height and diameter of white ash and black walnut outplanted with and without autumn olive at the Rendleman tract after years 4 through 7

	Year[a]			
Treatment	4	5	6	7
		Height (m)		
Ash alone	2.86a	3.31a	3.74a	3.42a
Ash/autumn olive	2.98a	3.30a	4.00a	4.44b
Walnut alone	0.58a	0.65a	0.64a	0.78a
Walnut/autumn olive	0.73a	0.87a	1.04b	1.40b
		Diameter (cm)		
Ash alone	33.15a	41.10a	43.74a	44.80a
Ash/autumn olive	36.15a	42.40a	44.65a	48.40b
Walnut alone	9.35a	10.00a	8.60a	11.30a
Walnut/autumn olive	11.50a	12.35a	11.70b	14.75b

[a]Means within the same column and species followed by the same letter are not significantly different at the 0.05 level.

Table 3.—Height and diameter of white oak outplanted at two locations, with and without autumn olive, after years 4 through 7

Location	Autumn olive	Year[a]			
		4	5	6	7
		Height (m)			
Rendleman	Without	0.60a	0.95a	1.20a	1.77a
Rendleman	With	0.79a	1.40b	1.84b	2.39b
Goolsby	Without	0.71a	0.90a	1.69a	2.05a
Goolsby	With	1.10b	1.62b	2.25b	2.93b
		Between locations			
Rendleman		69.25a	117.50a	151.50a	207. 75a
Goolsby		91.33a	130.13a	205.33b	257.00a
		Diameter (cm)			
Rendleman	Without	9.55a	13.10a	19.45a	28.15a
Rendleman	With	11.38b	18.55b	25.90a	35.70b
Goolsby	Without	12.90a	14.90a	19.60a	25.61a
Goolsby	With	16.52a	21.63b	22.94a	28.27a
		Between locations			
Rendleman		10.45a	15.60a	22.68a	31.92a
Goolsby		14.95b	17.91a	20.82a	27.02a

[a]Means within the same column for a parameter followed by the same letter are not significantly different at the 0.05 level.

White oak planted with autumn olive averaged 30 and 25% taller than white oak planted alone at the Goolsby and Rendleman tracts, respectively (Table 3). Height differences were not significant until year 4 at the Goolsby tract and year 5 at the Rendleman tract. Trees planted with autumn olive also had larger diameters than white oak planted alone (Table 3). However, at the Goolsby tract, the difference between diameters for the two treatments was significant only for year 5. By year 7, the trees at the Goolsby tract were taller and smaller in diameter than trees at the Rendleman tract, but the difference was not significant. Height and diameter differences between locations were significant (a = 0.05) in year 6 and year 4, respectively.

Nutrient Elements

Soil nitrogen in all plots ranged from 0.10 to 0.13% (Tables 4 and 5). Differences between soil nutrients among treatments were not significant in ash and walnut plots. There were no significant differences between treatments for oak plots at the Goolsby tract, but there were differences at the Rendleman tract (Table 5). Potassium, calcium, and magnesium were higher at the Goolsby tract than at the Rendleman tract.

Foliar nitrogen was higher in leaves from trees planted with autumn olive than in leaves from trees planted alone (Table 4). With autumn olive, leaf nitrogen averaged 2.6 and 2.8% for white ash and black walnut, respectively, compared to 1.4 and 1.7%, respectively, without autumn olive. Both foliar calcium and magnesium were higher in the walnut-alone treatment than in the walnut/ autumn olive mixture; the opposite was true for magnesium in ash leaves.

Table 4.—Concentration of nutrient elements in soil and leaves of trees in white ash and black walnut plots.

Treatment	Nutrient element[a]					
	N	P	K	Ca	Mg	Mn
	(%)	- - - - - - - - -	(µg/g of sample)	- - - - - - - - -		
Soil						
Ash alone	0.10a*	48a	71a	344a	41a	381a
Ash/autumn olive	0.11a	58a	72a	293a	35a	383a
Walnut alone	0.12a	58a	88a	363a	42a	382a
Walnut/autumn olive	0.10a	45a	65a	409a	36a	334a
Leaves						
Ash alone	1.4a	1,185a	10,823a	8,592a	1,385a	159a
Ash/autumn olive	2.6b	1,314a	9,398a	9,386a	2,069b	170a
Walnut alone	1.7a	1,507a	9,604a	20,853a	3,129a	401a
Walnut/autumn olive	2.8b	1,313a	9,195a	15,085b	2,494b	470a

[a]Key to symbols: N = nitrogen; P = phosphorus; K = potassium; Ca = calcium; Mg = magnesium; Mn = manganese.

*Means within the same column and species followed by the same letter are not significantly different at the 0.05 level.

Nitrogen levels were also higher in leaves from white oaks planted with autumn olive than from white oaks planted alone at both locations (Table 5). Both magnesium and manganese were higher in the leaves of white oak mixed with autumn olive than in white oak alone at the Goolsby tract, but magnesium was higher in the white oak-only plot at the Rendleman tract. Nitrogen and manganese levels were higher in oak leaves at the Rendleman tract than at the Goolsby tract.

DISCUSSION

Survival was good for all three tree species at both sites; however, both ash and walnut had considerable dieback resulting in multiple stems in some instances. In such cases, had all of the biomass been in one stem, measured growth might have been more. Compared to walnut and ash, fewer oaks died back, but their overall height was intermediate between the other two species.

Neither site has soil recommended for good hardwood growth, especially black walnut (Losche 1973). Soils have sufficent depth, but they are somewhat poorly drained; well drained soil is recommended. The mean height (1.4 m) of walnut was significantly taller in the autumn olive/walnut mixture than in the walnut-only plots, but this height was much less than the 2.7 m reported for another 7-year-old walnut (Van Sambeek *et al.* 1985) or the 6.8 to 5.1 m reported for 9-year-old walnut (Funk *et al.* 1979)

Finn (1953) reported that white oak planted with black locust had 0.5% more nitrogen than white oak planted alone. In the present study, the oak, ash, and walnut planted with autumn olive averaged nearly 0.2, 0.5, and 0.4%, respectively, more leaf nitrogen than trees planted alone.

Table 5.—Concentration of nutrient elements in soil and oak leaves at two locations

Location	Autumn olive	Nutrient element[a] N	P	K	Ca	Mg	M
		(%)	-------- (µg/g of sample) --------				
Soil							
Rendleman	Without	0.12a*	48a	88a	571a	64a	437a
Rendleman	With	0.10a	48a	56a	343b	36b	399a
Goolsby	Without	0.13a	32a	116a	1912a	126a	376a
Goolsby	With	0.13a	33a	103a	2143a	130a	353a
				Between locations			
Rendleman		0.11a	48a	72a	457a	50a	418a
Goolsby		0.13a	33a	110b	2028b	128b	365a
Leaves							
Rendleman	Without	2.00a	1286a	6138a	14570a	1071a	584a
Rendleman	With	3.05b	1538a	8015a	13489a	1640b	511a
Goolsby	Without	1.73a	1414a	6411a	15828a	1225a	174a
Goolsby	With	3.10b	1506a	7064a	14323a	1701b	282b
				Between locations			
Rendleman		2.78a	1412a	7077a	14030a	1356a	548a
Goolsby		2.42b	1460a	6738a	15076a	1463a	228b

[a]Key to symbols: N = nitrogen; P = phosphorus; K = potassium: Ca = calcium: Mg = magnesium: Mn = manganese.

*Means for a location or between locations followed by the same letter are not significantly different at the 0.05 level.

Trees at the Goolsby tract were taller but smaller in diameter than trees at the Rendleman tract. The smaller diameter of the trees can probably be attributed to the crowding caused by the autumn olive, which grew faster at the Goolsby tract than at the Rendleman tract. The autumn olive outgrew many of the oaks by as much as 0.8 m in 1985, and by 0.5 m in 1988, after being cut back to near ground level. The crowding probably created an effect described as "fur coat," which tends to increase height growth at the expense of diameter growth (Ivanova 1953). Ivanova (1953) reported that young oaks grew well in protected, lateral shade conditions provided by accessory species similar to the environment created by autumn olive (Funk *et al.* 1979). The favorable effect of the "fur coat" ceases when autumn olive outgrows the oak and interferes with its height growth.

Trees and autumn olive in this study were planted at a closer spacing than those reported for several other mixed plantings (Table 6). Therefore, trees in closer spaced plantings might respond sooner to the autumn olive than trees in more widely spaced plantings. However, growth differences attributed to autumn olive were not apparent until year 4, which is within the usual range of years reported for other studies (Table 6).

Table 6.—Initial black walnut growth response to interplanted species and spacing

Source	Between walnuts in the row	Between rows	Between inter-planted species	Years before response
	- - - - - - - - - - - Meter	- - - - - - - - - - -		Number
This study	2.4	3.1	1.2	4 to 5
Schlesinger and Williams 1984	4.9	3.7	2.5	4 to 5
	3.4	3.4	1.7	4 to 5
Van Sambeek et al. 1985	4.2	3.0	3.3	5 to 6

Friedrich and Dawson (1984) reported that soil nitrogen concentration in more closely spaced (3.7 x 4.9 m) plots of autumn olive and black walnut was higher than in wider spaced (3.7 x 9.8 m) plots, but the size of the walnut was not closely correlated with the accrued soil nitrogen in mixed plots. Walnut size was generally greater in mixed plots at the wider 3.7 x 9.8 m spacing. This suggests that soil nitrogen accounts for only a part of the growth difference attributed to interplanted nitrogen-fixing species. Other factors such as reduced weed competition, wind protection, lower air and soil temperatures, and higher canopy humidity might be associated with the better growth of trees in mixed plots.

Interplanting autumn olive has significantly increased the growth of associated hardwood in plantings on both sites and for all three species in this study. However, results from this study do not provide evidence that a site previously occupied by autumn olive is superior to a site previously occupied by scattered hardwoods and shrubs in promoting growth of planted trees.

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