EFFECT OF WEED CONTROL ON EARLY GROWTH AND SURVIVAL OF PLANTED BLACK WALNUT IN A FOREST CLEARCUT[1/]

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Abstract.--Black walnut (Juglans nigra L.) seedlings were planted in a hardwood forest clearcut to evaluate their growth in response to weed control treatments. After 3 years, control plots consisted mainly of woody vegetation with very few herbaceous species. Controlling woody sprouts increased herbaceous vegetation. Both woody and herbaceous weeds were reduced in the treatment to control herbaceous weeds. Survival of walnut trees on plots treated to control herbaceous weeds was significantly better than where only woody sprouts or no vegetation was controlled. Both height and diameter of black walnut were increased with weed control when compared with no weed control. Survival, height, and diameter were best on better sites.

Keywords: herbaceous weeds, height growth, planting, dieback

The absence of black walnut (Juglans nigra L.) in upland timber stands suggests that such sites are not suitable for the species. Yet many of these sites are capable of growing high-quality timber and could be planted to walnut after clearcutting (Hilt 1977). Seedlings planted after a regeneration cut must compete with fast-growing woody sprouts of the cutover trees and shrubs that have well-established root systems. Many herbaceous weeds also invade these forest openings, creating vegetational conditions similar to the herbaceous competition in old-field plantings (von Althen 1976). Thus, the planted seedlings must be kept free of competition by using cultural treatments that are usually expensive to apply. The cost involved may be offset by the high value of the species and the potential for rapid growth on good sites.

Krajicek (1975) reported that planted walnut trees grew well in forest clearcuts if vegetation was controlled. Trees grew somewhat larger where all competing vegetation was controlled but grew almost as large where only herbaceous competition was controlled. The factors responsible for the effect need to be clarified: is the control of herbaceous vegetation or woody sprouts more conducive to the improved growth? The current study reports on the effect of controlling herbaceous vegetation and woody sprouts on growth of black walnut planted in a hardwood clearcut.

METHODS AND MATERIALS

A recent timber sale in an upland cove containing mixed hardwoods on the Kaskaskia Experimental Forest in Hardin County, Illinois, provided a suitable area for the study. The harvested overstory consisted mainly of white oak (Quercus alba L.), black oak (Q. velutina Lam.), blackgum (Nyssa sylvatica Marsh.), and yellow poplar (Liriodendron tulipifera L.) with sugar maple (Acer saccharum Marsh.) in the understory. Debris and the remaining trees were moved off the study site after the sale was completed in late summer.

Soils on the site belong to the Baxter series (clayey, mixed, mesic, Typic Paleudults). The soil is cherty and well drained; and it has a subsoil that extends to a depth of 150 cm or more. Slopes range from 10 to 25 percent. The area is dissected by several intermittent streams. The following nutrient levels were determined according to routine analysis from nine composite soil samples collected at the 0-25 cm depth in late summer after the timber sale: pH, 5.1; NO_3-N, 27 ppm; P, 25 ppm; K, 162 ppm; Ca, 1534 ppm; and Mg, 133 ppm. Site index for upland oak based on white and red oak on the site was 65-75 (Soil Conservation Service 1975).

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The study area was divided into three blocks that differed in slope position and aspect. Within each block four treatments were randomly assigned to 6.1- x 4.9-m plots in a randomized complete block design. Treatments included: (1) no weed control, (2) woody sprout control, (3) herbaceous vegetation control, and (4) herbaceous vegetation and woody sprout control. Treatments were applied in the spring after most of the woody perennials had broken bud. Woody sprouts (treatments 2 and 4) were sprayed with glyphosate at a rate of 2.2 kg/ha (active ingredient) and stumps were sprayed with 2,4,5-T at a rate of 0.85 kg/ha (active ingredient). Simazine and glyphosate were applied at a rate of 5.6 and 2.2 kg/ha, respectively, in treatments 3 and 4. Treatments were repeated in the spring for the next 2 years. Stovepipes were used to keep chemicals off study seedlings during chemical applications.

Twenty-five nursery-grown 1-0 black walnut seedlings were planted in each 5-row plot in early spring before bud break of native vegetation. Seedlings were planted in rows at 3- x 3-m spacing. Trees in each plot were measured for total height and diameter at 2.5 cm above the ground after planting and in the fall annually. Data were analyzed as a randomized complete block design with four treatments. Differences between means were tested using the Duncan's new multiple range test at the 0.05 level.

Because of the very dense vegetation created by the large number of woody sprouts and blackberry (Rubus spp.) that had in some instances emerged as the dominant vegetation, weed species were recorded but not quantified.

RESULTS

Weed Control

Weeds targeted for control were not completely eradicated from plots by herbicide treatments. Occasional bare soil surface areas were present in herbicide-treated plots, especially in the complete weed control treatment. These areas did not cause any noticeable erosion.

The species composition of weeds on plots was influenced by herbicide treatments (table 1). As expected, the control treatment had the most diverse and largest number of woody species compared to other treatments. Controlling only woody sprouts substantially increased herbaceous species. Except for crab grass and a few scattered clumps of broomsedge, plots treated to control herbaceous species lacked grasses found in plots to control woody sprouts. In addition to the other tree species, dogwood and pignut hickory were also on plots treated to control herbaceous weeds. Except for herbaceous species in control plots, fewer trees and herbaceous species were present in the complete weed control treatment than in other treatments. Sassafras, a pioneering species, was present on all treated plots. Because sassafras almost always occurs as root suckers in clearcuts, chemical control was not effective.

Survival

The percent survival of the black walnut seedlings declined during the study (table 2). After three growing seasons, mean survival of walnut trees on plots treated to control herbaceous weeds was much better than where only woody sprouts or no vegetation was controlled (81 vs 41 and 35%, respectively). Also, survival was influenced by position (blocks) on the landscape. Survival was better in block III on the lower south-facing slope (78%) than in block I (67%) and block II (71%), which were on upper slopes with southwestern and northeastern aspects, respectively. The major causes of walnut mortality in all blocks appear to be droughty soils as may be the case on the upper slopes and suppression by weeds, especially in treatments 1 and 2.

Height and Diameter

Some shoot dieback occurred during the first growing season; however, the amount increased much more after the first winter, resulting in negative net height for all treatments (table 2). The amount of shoot dieback was greatest in the control, followed by control of woody sprouts > control of herbaceous vegetation > control of woody sprouts + herbaceous vegetation (complete).

By the end of the third growing season, only trees in treatments 3 and 4 exceeded their original height (table 2). Trees in plots treated to control herbaceous weeds were taller and larger in diameter than trees in other treatments, averaging 18.7 cm taller than trees in treatment 4 and more than 30 cm taller than trees in treatments 1 and 2. However, the growth difference between treatments 3 and 4 was not significant.

Diameter followed the same trend as height (table 2). Trees in plots treated to control herbaceous weeds only were larger in diameter than trees in the control and in plots treated to control woody sprouts but were not significantly larger than trees in the plots treated to control both herbaceous vegetation and woody sprouts.

DISCUSSION

The poorer growth of walnut trees in the control plots compared to other treatments is likely due to competition from woody vegetation in plots for moisture and light. Some of the woody species developed from seeds while many more developed from surviving stumps. The root systems of plants that developed from stump sprouts were well developed and provided root competition for planted walnut seedlings. The root system of black walnut combines the deep tap root of the more xeric trees with the strong laterals characteristic of the more

Table 1.--Occurrence of plants in a 3-year-old black walnut plantation planted in a forest clearcut with several weed control treatments

	Vegetation controlled			
	Control (none)	Woody sprouts	Herbaceous	Complete (all)
Trees or woody				
Red oak[1/]	X[2/]	X	X	
White oak	X	X	X	
Pignut hickory	X		X	
Black cherry	X			X
Black oak	X			
Sugar maple	X			
Redbud	X			
Dogwood	X		X	
Sassafras	X	X	X	X
Yellow poplar	X		X	
Grape	X	X		
Smooth sumac		X	X	X
Herbaceous				
Blackberry	X	X		
Virginia creeper		X	X	X
Broomsedge		X	X	X
Poverty oak grass		X		
Yellow wood sorrel		X	X	
False solomon's seal			X	
Trumpet-weed			X	X
Bush honeysuckle	X	X		X
Asters		X		X
Ragweed				X
Crab grass		X	X	X
Tall fescue		X		

[1/]Red oak (*Quercus rubra* L.); white oak (*Q. alba* L.); pignut hickory (*Carya glabra* (Mil.) Sweet); black cherry (*Prunus serotina* Ehrh.); black oak (*Q. velutina* Lam.); sugar maple (*Acer saccharum* Marsh.); redbud (*Cercis canadensis* L.); dogwood (*Cornus* spp. L.); sassafras (*Sassafras albidum* (Nutt.) Nees.); yellow poplar (*Liriodendron tulipifera* L.); grape (*Vitis* spp. L.); blackberry (*Rubus* spp. L.); smooth sumac (*Rhus glabra* L.); Virginia creeper (*Parthenocissus quinquefolia* (L.) Planch.); broomsedge (*Andropogon virginicus* L.); poverty oat grass (*Danthonia spicata* (L.) Beauv.); yellow wood sorrel (*Oxalis stricta* L.); false solomon's seal (*Smilacina stellala* (L.) Desf.); trumpet-weed (*Eupatorium fistulosum* Barratt.); bush honeysuckle (*Diervilla ionicera* Mill.); aster (*Aster* spp. L.); ragweed (*Ambrosia bidentata* Michx.); crab grass (*Digitaria sanguinalis* (L.) Scop.); tall fescue (*Festuca arundinacea* Schreb.).

[2/] Common on treated plot.

mesic trees. However, in most cases, almost 80% of black walnut's root system is in the upper 61 cm of the soil layer (Pham *et al.* 1978). This, combined with black walnut's ability to make food in rather low light intensities, suggests that soil moisture may be more restricting to growth than light in this study (Holch 1931).

Controlling woody sprouts only enhanced the invasion of herbaceous species. Evidence in the literature suggests that droughty soil conditions resulting from root competition are important in some cases, but the competition of tree roots in the vicinity of the planted seedlings is less to be feared than the competition of herbaceous vegetation (Burke and Williams 1973, Holch 1931, Lane and McComb 1948, Wright 1985).

Part of the better growth of trees in plots treated to control herbaceous weeds must also be attributed to the reduction of woody sprouts. The use of the contact herbicide, glyphosate, in

Table 2.--Mean height, diameter, and survival of planted black walnut

Weeds controlled	Height data: Initial height	Shoot dieback 1st year	Mean tree height after 1st year	2nd year	3rd year
	cm				
1. None (control)	61.0 a[1/]	21.4 a	39.6 a	39.6 a	49.8 a
2. Woody sprouts	64.0 a	18.3 a	45.7 a	45.7 a	53.8 a
3. Herbaceous vegetation	64.0 a	9.1 b	54.9 b	54.9 b	87.4 b
4. Complete (all)	64.0 a	3.0 b	61.0 b	45.7 a	68.7 b

Weeds controlled	Diameter data: Initial diameter	Diameter lost to dieback 1st year	Mean tree diameter after 1st year	2nd year	3rd year
	mm				
1. None (control)	9.5 a	0.5 a	10.1 a	9.2 a	9.6 a
2. Woody sprouts	9.6 a	0.0 a	10.0 a	9.6 a	10.5 a
3. Herbaceous vegetation	9.6 a	0.0 a	10.7 b	10.6 b	13.6 b
4. Complete (all)	9.8 a	0.0 a	10.8 b	10.8 b	12.2 b

Weeds controlled	Survival data: Trees planted	Mean survival after 1st year	2nd year	3rd year
	No.	Percent		
1. None (control)	75	81 a	60 a	35 a
2. Woody sprouts	75	79 a	52 a	41 a
3. Herbaceous vegetation	75	91 ab	85 b	81 b
4. Complete (all)	75	95 b	84 b	81 b

1/ Values within a column followed by the same letter do not differ significantly at the 0.05 percent level according to Duncan's new multiple range test.

the herbaceous weed treatment killed both broadleaved and narrowleaved plants. Thus, some woody sprouts were likely killed in addition to herbaceous weeds in plots where only herbaceous weeds were to be controlled. Also, because 2,4,5-T was used on sprouts, some broadleaved herbaceous weeds were also likely killed.

Root competition for moisture and nutrients undoubtedly accounts for the death or slow growth of trees in this study. Controlling only woody sprouts increased herbaceous weed competition. Herbaceous vegetation appears to be more effective than trees in removing moisture from the upper soil layers where the roots of trees are most abundant and consequently more dependent on available soil moisture at this soil depth. Because controlling both woody sprouts and herbaceous vegetation is important, trees in treatment 4 may outperform trees in treatment 3 in the long run.

It is impractical to control only herbaceous vegetation in hardwood clearcuts because of the vegetative component in the vicinity of the seedling and the assortment of approved chemicals that are most economical for this purpose. However, the main emphasis of weed control in the establishment of black walnut in clearcuts should be, as in old-field plantings, to control herbaceous weeds to enhance growth during the establishment years.

This study suggests that providing herbaceous or complete weed control for black walnut planted in hardwood clearcuts will increase their survival, height, and diameter in comparison to trees receiving treatments to control woody sprouts or no weed control. Trees in the better growing treatments were on the average 26 cm taller, 3 mm larger in diameter, and had a 40% higher survival rate than trees in the slower growing treatments. However, after three growing seasons, trees in the better growing treatments grew less than trees usually grow in old field plantings (Bey and Williams 1976, Erdmann 1976). One reason for this may be associated with the lower soil nutrient levels recorded for the site. Thomson and McComb (1962) and Ponder and Baines (1985), except for NO_3-N, reported higher levels of P, K, Ca, and Mg in soil where natural and planted black walnut grew.

At least 3 years of weed control are recommended for black walnut planted on old fields; however, because of black walnut's potentially high value, it may be economical and desirable to extend that period by 1 or more years. In

addition, an early release may be in order some time later in this mostly natural regenerating stand (Hilt 1977).

Three years represent a small fraction of the time required for black walnut to develop crowns in the dominant-codominant class within the stand. However, it seems reasonable, even at this early age of the walnut, to speculate that treatments providing herbaceous and complete weed control will enhance the black walnut component of this future stand. Periodic measurements over the coming years will be necessary to evaluate this study as a way of introducing black walnut into natural stands.

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