Effects of weed control on the survival and growth of planted black walnut, white ash and sugar maple

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Les effets du contrôle des mauvaises herbes sur la survie et la croissance des semis de noyer noir, frêne blanc et érable à sucre. L'influence de trois contrôles mécaniques, de quatre méthodes chimiques et de quatre traitements organiques contre les mauvaises herbes a été comparée à l'intérieur de trois essais expérimentaux dans l'Ontario méridional. On étudia ainsi le pourcentage de survie ainsi que la croissance des semis de noyer noir, frêne blanc et érable à sucre, plantés sur sol modérément bien drainés constitué d'une argile limoneuse.

Tous ces traitements purent contrôler la croissance des mauvaises herbes durant la première année. Par contre seuls, l'amendement de 9 et 12 livres/acre de Simazine, l'installation de feuilles de polythène noir, de 4 pieds de largeur, et l'utilisation de la bêcheuse rotative durant 2 ans, purent tenir en respect la compétition des herbes indésirables durant la troisième année.

La survie du noyer noir ne fut pas influencée par les traitements de façon significative; par contre, celle du frêne blanc fut nettement diminuée par des amendements de Simazine dépassant 3 livres/acre. Quant à l'érable à sucre, sa survie fut peu convaincante quel que fut le traitement en cause.

La meilleure croissance du noyer noir fut reconnue dans les parcelles traitées au moyen de 9 et 12 livres/acre de Simazine, alors que celle du frêne blanc s'obtenait dans les parcelles traitées organiquement et munies de polythène noir.

Le coût/bénéfice le plus élevé provient de l'application de la Simazine suivant un traitement de 3 livres/acre.

Weed control is a necessary prerequisite to successful hardwood afforestation, because most hardwood species are unable to compete successfully with weeds and grasses during the early years after planting (von Althen 1964, Bell et al. 1968). Manual and mechanical methods of weed control have proven very successful (Byrnes 1966), but the frequency of operations required for effective control makes these methods rather expensive. Herbicides offer a more economical control (White 1967), but many hardwood seedlings are damaged by the dosages necessary for effective weed control (Erdmann 1967). Weeds and grasses may also be controlled through mulching with additional benefits accruing from reduced surface evaporation (Gabriel 1962) and soil temperature extremes (Waggoner et al. 1960). Improved seedling survival and growth after mulching have also been reported as the result of increased average soil temperature (Stephens 1965), as an accumulation of nitrates (Black and Greb 1962), or as a reduction in the rate of nitrate leaching (Clarkson 1960).

This paper reports the results of three studies carried out to determine the effects of various weed control treatments upon the early survival and growth of planted black walnut (*Juglans nigra* L.), white ash (*Fraxinus americana* L.), and sugar maple (*Acer saccharum* Marsh.).

Methods

All seedlings were planted in a former agricultural field located on a flood plain of the Ausable River near Parkhill in southern Ontario. The soil was a moderately well drained, deep, very uniform alluvial silty clay. Weed growth was very vigorous with the following species being most common on the site: goldenrod (*Solidago* spp.), wild aster (*Aster* spp.), milkweed (*Asclepias* spp.), teasel (*Dipsacus sylvestris* Huds.), Canada thistle (*Cirsium arvense* (L.) Scop.), quackgrass (*Agropyron repens* (L.) Beauv.), chess (*Bromus secalinus* L.), and downy brome grass (*Bromus tectorum* L.).

All planting was done in spring after the fields had been plowed and tilled the previous autumn. Weed control was assessed by ocular estimate of the density and vigor of the ground cover (Figure 1). Seedling survival and height growth were recorded each autumn for three years and the data were subjected to analyses of variance.

Study 1. Sixteen black walnut (1 + 0), white ash (2 + 0), and sugar maple (2 + 0) seedlings were planted per treatment in the spring of 1966 in a randomized block arrangement with four replications. Treatments consisted of: a/ mulching with a 4-ft-wide cover of black polyethylene film, .004 in. thick; b/ rototilling in June and July of the first year; c/ rototilling in June and July of the first 2 years after planting; and d/ a single application of 3 lb/acre active Simazine¹ sprayed in 3-ft-wide band shortly after planting.

Study 2. Twenty black walnut (1 + 0), white ash (2 + 0), and sugar maple (2 + 0) seedlings were planted in each treatment in the spring of 1967 in randomized block arrangement with three replications. Treatments consisted of: a/ mulching with a 4-ft-wide cover of black polyethylene film, .004 in thick; and b to e/ a single application of active Simazine (wetttable powder) at a per acre dosage of 3, 6, 9, or 12 lb.

Study 3. Nine black walnut (1 + 0) seedlings were planted in each treatment in the spring of 1966 in a randomized block arrangement with six replications.

¹Simazine is now distributed in Canada under the registered trade name of "Princeps", the name by which it has been known in Europe and the United States.

Fig. 1. Illustration of weed control rating. Upper photograph shows 20% weed control; lower photograph, 90% weed control.

Treatments consisted of: a/ mulching with a 4-ft-wide cover of black polyethylene film, .004 in. thick; b/ mulching with a 4-ft-wide cover of clear polyethylene film, .004 in. thick; c/ mulching with a 3-ft-wide

TABLE 1. Effectiveness of weed control by studies, treatments, and years since application

Treatments	Effectiveness of weed control in percent ^a		
	First year	Second year	Third year
Study 1			
Black polyethylene 4' wide.....	90	70	30
Rototilled for 1 year.....	90	20	0
Rototilled for 2 years.....	90	90	30
Active Simazine 3 lb/acre.....	80	20	0
Study 2			
Black polyethylene 4' wide.....	90	70	30
Active Simazine 3 lb/acre.....	80	20	0
Active Simazine 6 lb/acre.....	80	40	10
Active Simazine 9 lb/acre.....	90	70	40
Active Simazine 12 lb/acre.....	90	90	60
Study 3			
Black polyethylene 4' wide.....	90	70	30
Clear polyethylene 4' wide.....	90	50	10
Black polyethylene 3' wide.....	90	40	0
Clear polyethylene 3' wide.....	70	30	0
Manual weeding.....	80	20	0

^a0 = no control, 100 = all weeds eradicated.

cover of black polyethylene film, .0015 in. thick; d/ mulching with a 3-ft-wide cover of clear polyethylene film, .002 in. thick; and e/ manual weeding in June and July of the first year after planting.

Results

All treatments controlled weed growth effectively during the first year, but only 4-ft-wide covers of black polyethylene, 9 and 12 lb/acre dosages of active Simazine or rototilling for 2 years provided an effective relief from competition during the third year (Table 1).

Walnut survival was not significantly affected by treatments, but ash survival was significantly reduced at dosages of more than 3 lb/acre of active Simazine (Table 2). The sensitivity of white ash to higher concentrations has previously been recorded (von Althen 1970). Survival of sugar maple was unsatisfactory under all treatments.

Walnut obtained its best growth after application of 9 and 12 lb/acre of active Simazine, while ash grew best in plots mulched with 4-ft-wide strips of black polyethylene and those rototilled for 2 years. Growth of sugar maple was unsatisfactory under all treatments.

Economic analysis of treatments

Although the success of a plantation must never be sacrificed for an initial saving in establishment costs, the choice of weed control will largely depend on the cost benefit of each treatment. To facilitate a cost-benefit comparison between all treatments tested, possible growth differences between years of planting caused by differences in climatic conditions or planting stock quality were ignored. All data were computed on the basis of 1 acre planted with 907 trees at a spacing of 8 by 6 ft (Table 3). To obtain a standard comparison relating the differentials in survival and growth of the different treatments, average growth per tree was multiplied by the number of trees per acre (907) and the percent survival for the same treatment.

Cost data for each treatment were calculated on the following basis: manual weeding of 3-ft-wide strips, at \$2.50/hr; rototilling of the total area with a tractor at \$9.00/hr; polyethylene film applied by hand in 3- or 4-ft-wide continuous strips over the centre of each row of trees and thereby covering an area of 16,326 and 21,768 sq ft/acre, respectively; Simazine applied in 30 gal of water/acre with a motorized sprayer over the total area.

To obtain the cost benefit of each treatment, the total linear growth of stems per acre was divided by the total cost of cultivation.

Discussion

The necessity of weed control in newly established hardwood plantations is an acknowledged

TABLE 2. Three-year survival and height growth of planted black walnut, white ash, and sugar maple seedlings by studies and treatments

Treatments	Survival			Height growth		
	Walnut (%)	Ash (%)	Maple (%)	Walnut (in.)	Ash (in.)	Maple (in.)
Study 1						
Black polyethylene 4' wide.....	89	89	20 ^a	21	32	0 ^a
Rototilled for 1 year.....	94	86	19	15	21 ^b	0
Rototilled for 2 years.....	93	86	33	31 ^b	38	10
Active Simazine 3 lb/acre.....	92	66	17	13	14 ^b	0
Study 2						
Black polyethylene 4' wide.....	95	98	23	28	45	4
Active Simazine 3 lb/acre.....	100	100	3	25	30 ^b	4
Active Simazine 6 lb/acre.....	98	65 ^b	8	30	18 ^b	10
Active Simazine 9 lb/acre.....	95	40 ^b	25	39	11 ^b	12
Active Simazine 12 lb/acre.....	100	27 ^b	5	34	9 ^b	3
Study 3						
Black polyethylene 4' wide.....	91	—	—	25	—	—
Clear polyethylene 4' wide.....	87	—	—	23	—	—
Black polyethylene 3' wide.....	93	—	—	19 ^b	—	—
Clear polyethylene 3' wide.....	78	—	—	19 ^b	—	—
Manual weeding.....	68	—	—	18 ^b	—	—

^aNo significant difference shown because of inadequate survival and growth under all treatments.

^bSignificantly different from black polyethylene 4-ft-wide at the p .05 level.

fact, but treatment choice greatly depends on tree species, competing vegetation, plantation soil, and costs.

Manual and mechanical cultivation controlled weed growth effectively for short periods, but had to be repeated for long-term control. The additional benefits of increased soil aeration and water infiltration and the reduction in surface evaporation recommend manual and mechanical cultivation for use on heavy textured soils which are subject to crusting and compaction. These methods are also useful

for species which are highly susceptible to Simazine.

Black polyethylene film provided somewhat more effective weed control than clear polyethylene which acted, at times, like a hothouse for the germinating weeds. Goldenrod, Canada thistle, and teasel were, therefore, sometimes able to lift the clear film, while the pointed shoots of quackgrass grew through the film. Four-foot-wide strips of polyethylene film, .004 in. thick, controlled weed growth longer and more effectively than 3-ft-wide strips of either .0015- or .002-in-thick film. Extremely high temperatures un-

TABLE 3. Cost benefit of cultivation treatments

Treatments	Per acre cost of treatment			Total linear height growth/acre		Net growth per dollar spent on cultivation	
	Material (\$)	Labour (\$)	Total (\$)	Walnut (ft)	Ash (ft)	Walnut (ft)	Ash (ft)
Study 1							
Black polyethylene 4' wide.....	133	70	203	1435	2122	7	10
Rototilled for 1 year.....	0	18	18	1065	1347	59	75
Rototilled for 2 years.....	0	36	36	2174	2469	60	69
Active Simazine 3 lb/acre.....	10	3	13	1389	695	107	53
Study 2							
Black polyethylene 4' wide.....	133	70	203	2008	3330	10	16
Active Simazine 3 lb/acre.....	10	3	13	1888	2265	145	174
Active Simazine 6 lb/acre.....	20	3	23	2220	883	97	38
Active Simazine 9 lb/acre.....	31	3	34	2801	340	82	10
Active Simazine 12 lb/acre.....	41	3	44	2567	181	56	4
Study 3							
Black polyethylene 4' wide.....	133	70	203	1721	—	8	—
Clear polyethylene 4' wide.....	128	70	198	1510	—	8	—
Black polyethylene 3' wide.....	56	70	126	1336	—	11	—
Clear polyethylene 3' wide.....	48	70	118	1117	—	9	—
Manual weeding.....	0	150	150	921	—	6	—

der the black polyethylene film, e.g., a maximum of 146°F measured on 13 July 1966, caused stem lesions wherever the mulches touched the stems (Figure 2). This damage was, however, easily avoided in later experiments by cutting larger holes in the film or by placing one shovelful of soil around each seedling on top of the film.

The greatest disadvantage of mulching with polyethylene film was the difficulty of application. Several machines exist today which spread the film on the ground and cover the edges with soil to prevent the sheets from blowing away. However, no satisfactory mechanical system has yet been developed that allows simultaneous mulching and planting of rooted stock or mulching immediately following planting. In our studies all film was laid by hand after the trees had been planted. One man rolled out the film and cut the holes with a knife while another weighted down the sides with shovelful of earth.

Simazine, suspended in water and applied shortly after planting as a fine spray onto the plowed soil surface, proved to be very effective in retarding weed growth. Whereas 3 lb/acre of active chemical provided 80% weed control in the first year and 20% in the second year, 12 lb kept the soil surface 90% weed free for the first 2 years and still afforded a 60% control in the third year. However, only black walnut proved to be resistant to the higher dosages, while white ash and sugar maple were seriously damaged at dosages of more than 3 lb of active chemical/acre.

The failure of sugar maple to respond to any of the treatments indicates that weed control *per se* is not the only factor that inhibits the growth of this species in open-field plantations.

The cost-benefit determination shows that even highly significant growth increases were seldom able to compensate for higher treatment costs. The

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Fig. 2. Lesion on walnut stem after exposure to high temperature under black polyethylene film.

highest cost benefits were, therefore, nearly always obtained by treatments with the lowest costs. Black walnut and white ash obtained their highest cost benefits when 3 lb of active Simazine were used. The next best treatments for walnut were 6 and 9 lb of active Simazine. The second and third best treatments for white ash were rototilling for 1 and 2 years. It must be noted here also that rototilling for 2 years doubled the growth of black walnut and nearly doubled that of white ash rototilled for only 1 year.

On the basis of these results, dosages of 3 to 9 lb of active Simazine are recommended for weed control in walnut plantations and 3 lb/acre in white ash plantations growing on heavy-textured soils. Although the cost benefit of rototilling or mulching with 4-ft-wide black polyethylene was low, these treatments may be useful in plantings where costs are less important than assured success or on unfavorable sites where other treatments might fail.

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