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THE EFFECT OF FOUR HERBICIDES ON THE SURVIVAL AND GROWTH OF NINE HARDWOOD SPECIES

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ABSTRACT.--To learn more about the tolerance of hardwoods to herbicides, the survival and growth of nine hardwood species were compared in plots either cultivated or treated with various herbicides applied at different rates, on prepared and unprepared ground, and before and after planting. Black walnut and white oak were very tolerant to all herbicides tested but American sycamore and European alder were highly susceptible to herbicide damage by all chemicals tested except dichlobenil.

OXFORD: 414.4:176.1. KEY WORDS: simazine, atrazine, amitrole, dichlobenil.

Many hardwood plantations fail in their early years because of heavy weed competition. Weeds can be controlled by cultivation, but the need for frequent cultivation and topographic limitations have restricted the use of mechanical control. The development of herbicides has made it feasible to control weeds in forest plantings at relatively low cost; chemical control is also less restricted by topography. However, herbicides may not be used in tree plantations unless such use is specified on the container label and is not limited by a State or federal regulation.[1]

Information about the tolerance or susceptibility of various newly planted hardwood species to herbicides has been limited. To control weeds in mixed-species plantations we must know if the same chemicals and rates can be used safely for all species in the mixture. A recent study shows great differences in first-year survival and growth among nine hardwood species treated with four weed control chemicals at different rates.

METHODS

The study was established on the Shawnee National Forest in southern Illinois. The soil is Haymond silt loam, a well drained soil of the floodplain. It is slightly acid to neutral, moderately permeable, and has moderately high natural fertility.

Stratified black walnut (*Juglans nigra* L.) seed and 1-year-old seedlings of nine

[1]*This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.*

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife--if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

hardwood species, including walnut, were used in the study. The other species were white ash (*Fraxinus americana* L.), white oak (*Quercus alba* L.), sweetgum (*Liquidambar styraciflua* L.), black locust (*Robinia pseudoacacia* L.), American sycamore (*Platanus occidentalis* L.), river birch (*Betula nigra* L.), yellow-poplar (*Liriodendron tulipifera* L.), and European alder (*Alnus glutinosa* L.).

Four weed-control chemicals were tried alone or in combination--(1) dichlobenil alone, (2) atrazine-simazine (1:1), and (3) amitrole-simazine (1:3)--and at three different rates (table 1). Dichlobenil was applied before planting only; the atrazine-simazine and amitrole-simazine mixtures were applied before and after planting. Site preparation and tree planting were done in April.

Table 1.--*Weed control treatment*

Treatment	Rate (lbs/A)[1]	Weed cover June	Weed cover September	Weed height September
		- - - *Percent* - - -		*Feet*
Cultivation (control)	-	55	4	-
Dichlobenil (b)[3]	4	11	98	4
Dichlobenil (b)	6	10	92	3
Dichlobenil (b)	8	1	82	3
Atrazine-simazine (bp)[4]	1 + 1	12	100	3
Atrazine-simazine (bp)	2 + 2	10	84	2
Atrazine-simazine (bp)	3 + 3	6	70	2
Atrazine-simazine (ap)[5]	1 + 1	10	92	4
Atrazine-simazine (ap)	2 + 2	6	78	2
Atrazine-simazine (ap)	3 + 3	12	51[2]	2[2]
Amitrole-simazine (bn)[6]	0.5 + 1.5	25	89	3
Amitrole-simazine (bn)	1 + 3	16	84	3
Amitrole-simazine (bn)	1.5 + 4.5	15	84	2
Amitrole-simazine (an)	0.5 + 1.5	25	98	3
Amitrole-simazine (an)	1 + 3	20	88	2
Amitrole-simazine (an)	1.5 + 4.5	16	95	2

[1]Active ingredients (pounds per acre).
[2]Average of three plots. One contained 100 percent Johnsongrass 10 feet tall.
[3]b = before planting.
[4]p = plowed.
[5]a = after planting.
[6]n = not plowed.

The study area was an unimproved pasture that contained the native grasses plus scattered trumpet-creeper (*Campsis radicans* L.). Plots treated with dichlobenil and atrazine-simazine were prepared by plowing with a rotary tiller before the herbicides were applied. Plots treated with amitrole-simazine were not plowed before chemical treatment. The dichlobenil granules were broadcast, then lightly incorporated into the prepared soil. The wettable powder formulations of atrazine and simazine and the soluble powder formulation of amitrole were mixed with water and broadcast-sprayed on the surface. When herbicides were applied after planting, no effort was made to keep the spray off the dormant seedlings.

The 16 weed-control treatments were randomized in a complete block design that contained 4 blocks. Each treatment plot contained 10 rows of 10 trees or seed spots (one nut per spot) per row. A seedling of each species and a walnut seed were randomly assigned within each row. Thus, 40 seeds and 40 trees of each species were planted in each of the 16 weed-control treatments.

Spacing was 2 feet between and within rows.

Roots of all seedlings were pruned to 8 inches. Although seedling size varied among species, variation within a species was small. White oak and European alder, with top heights of 0.5 and 0.6 foot, respectively, were shortest. The tallest were river birch (1.5 feet) and American sycamore (1.4 feet). The other species' average heights ranged from 0.8 foot to 1.0 foot.

RESULTS

The only treatment that completely controlled the weeds and grasses was cultivation. Herbicides controlled the competing vegetation in early summer, but their effectiveness had diminished by late September (table 1). Predominant among the late germinating competition found on the plots in the fall were giant foxtail (*Setaria faberia* Herrm.) and fall panicum (*Panicum dichotomiflorum* Michx.). All other major weeds observed were the perennials: gray goldenrod (*Solidago nemoralis* Ait.), trumpet-creeper, horsenettle (*Solanum carolinense* L.), and yellow nutgrass (*Cyperus esculentis* L.). Johnsongrass (*Sorghum halepense* L.) had invaded on a small portion of the area.

The effects of the various herbicide treatments on the survival and growth of individual species are discussed below.

Black walnut seedlings.--Neither survival nor growth was adversely affected by any of the weed control chemicals (table 2). This supports the findings of Erdmann (1967) who found that black walnut seedlings were not damaged by either simazine or atrazine. He did, however, caution that atrazine should not be applied on sandy soils because it is leached more rapidly and to greater depths than simazine. In a greenhouse study, Wichman and Byrnes (1971) showed that black walnut can tolerate as much as 1.00 ppm of simazine and is more tolerant of simazine than of atrazine or diuron. In a field

Table 2.--*Mean survival percents and 1-year height growth, by treatments and species*

Species	Cultivated	Plowed: Dichlobenil lbs/A			Plowed: Atrazine plus simazine, Before planting lbs/A			Plowed: Atrazine plus simazine, After planting lbs/A			Unplowed: Amitrole plus simazine, Before planting lbs/A			Unplowed: Amitrole plus simazine, After planting lbs/A		
		4	6	8	1+1	2+2	3+3	1+1	2+2	3+3	0.5+1.5	1+3	1.5+4.5	0.5+1.5	1+3	1.5+4.5
SURVIVAL (PERCENT)																
Black walnut seedlings	100	95	100	92	95	100	98	100	100	100	100	100	100	100	98	100
Black walnut seed	62	48	48	42	60	68	50	62	55	40	35	48	50	45	68	45
River birch	100	90	88	88	82	62	48	92	78	42	100	92	82	100	100	88
Yellow-poplar	92	88	90	82	98	88	72	100	95	68	98	98	92	98	90	80
White oak	85	82	88	70	100	98	92	92	95	98	98	98	100	98	92	95
Sweetgum	100	100	92	98	98	88	92	100	100	95	98	95	98	100	98	95
American sycamore	100	95	82	88	65	20	10	50	12	10	75	45	28	75	12	15
European alder	88	90	82	88	55	18	15	38	2	0	75	50	25	65	30	18
Black locust	90	95	95	90	82	28	22	90	52	18	100	82	68	95	88	72
White ash	93	83	77	87	83	73	40	97	53	33	93	93	77	100	97	73
HEIGHT GROWTH (FEET)																
Black walnut seedlings	0.3	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.4
Black walnut seed	1.2	0.9	0.9	0.9	1.0	1.1	1.0	1.0	1.0	1.0	0.8	1.0	1.1	1.1	1.0	1.1
River birch	3.3	1.8	1.7	2.2	2.4	1.8	1.5	2.5	2.2	1.0	2.4	2.2	2.2	2.4	2.1	2.5
Yellow-poplar	1.7	0.5	0.3	0.5	0.9	0.9	0.5	0.9	0.8	0.4	0.6	1.0	0.9	0.8	0.6	1.0
White oak	0.4	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.2	0.3	0.2	0.3
Sweetgum	1.5	0.8	0.8	0.8	1.2	1.0	1.0	1.4	1.2	0.6	1.1	1.2	0.8	1.0	0.6	1.1
American sycamore	3.7	1.6	1.5	1.8	1.3	0.7	0.2	1.0	0.5	0.3	1.1	1.0	1.2	1.2	0.4	1.0
European alder	2.8	2.0	1.2	1.7	1.5	1.0	0.3	1.6	0.4	--	2.3	1.8	1.6	2.3	1.3	2.3
Black locust	7.2	4.4	3.9	3.6	4.1	4.3	1.9	4.8	3.8	1.3	4.4	4.3	4.2	4.7	4.2	3.4
White ash	2.1	0.8	0.4	0.8	0.6	0.4	0.3	0.7	0.4	0.3	1.0	0.8	0.7	1.1	0.6	0.3

study, Roth (1971) observed slight damage to walnut seedlings from an 8 pounds-per-acre rate of simazine, while an 8 pounds-per-acre rate of atrazine caused severe damage. Black walnut seedlings normally grow little the first growing season after planting, so the poor height growth was not attributed to the weed control treatments.

Black walnut seeds.--Seed germination was poor but survival differences among treatments were not great (table 2). In a more recent study we found damage and mortality to germinating walnut seed when an atrazine-simazine mixture (2+2 pounds) was used.

River birch.--River birch was damaged by herbicide mixtures containing 2 pounds or more of atrazine (table 2). However, river birch seems tolerant of simazine, especially at low rates. Survival of seedlings treated with atrazine-simazine ranged from 92 to 42 percent, but when amitrole was the other chemical mixed with simazine, survival ranged from 100 to 82 percent. Cultivated trees were twice as tall as those treated with the highest rates of atrazine-simazine.

Yellow-poplar.--Survival of yellow-poplar decreased as the rate of herbicide was increased, regardless of the chemical used (table 2). However, survival was 80 percent or more except when the highest rates of atrazine-simazine were used; simazine was also a part of the amitrole-simazine mixture, so it appears that atrazine is responsible for poor survival. Height growth of the cultivated trees was about double that of trees in herbicide-treated plots. These results for simazine and atrazine support the findings of Erdmann (1967). However, in their greenhouse study, Wichman and Byrnes (1971) found that yellow-poplar was very susceptible to damage by atrazine and only moderately tolerant of simazine.

White oak.--White oak appears to be tolerant of the chemicals at the rates used (table 2). Survival tended to be poorer when dichlobenil was used. Height growth, characteristically poor the first growing season, was poor for all treatments.

Sweetgum.--Sweetgum was tolerant of all chemicals, rates of application, and methods of application used. There were, however, small differences in height growth among the treatments.

Sycamore.--Survival of cultivated sycamore was 100 percent but 75 percent or less for all chemical treatments except dichlobenil (table 2). The extremely high mortality resulting from the chemical treatments other than dichlobenil shows the need for great caution when herbicides are tried. Height growth of cultivated sycamore was more than twice that of sycamore in any herbicide treatment.

European alder.--The survival of European alder was similar to that of sycamore: poor for all herbicides except dichlobenil (table 2). Survival of European alder was decreased more by atrazine-simazine applied after planting than to the same

chemicals applied before planting. Height growth of cultivated trees was best, but growth of some herbicide-treated trees was almost as good.

Black locust.--Survival of black locust was poor, 22 and 18 percent, when the atrazine-simazine mixture was applied at the highest rates (table 2). Survival was 90 percent or more in the dichlobenil plots. In plots treated with the amitrole-simazine mixture, survival was 82 percent or more for all but the highest rates. So, again, the more easily leached atrazine seems responsible for excessive mortality. Height growth for all treatments, except the two highest rates of atrazine-simazine, was good, but growth in the cultivated plots was far superior.

White ash.--Survival of white ash treated with dichlobenil was not correlated with rate. Survival was poor in plots treated with the 2+2 and 3+3 rates of the atrazine-simazine mixture and best for the two lower rates of amitrole-simazine (table 2). As noticed for other species, atrazine appears to be the harmful chemical. Although only 2.1 feet, height growth for the cultivation treatment was about double that for the best herbicide treatment and as much as seven times that of the poorest.

DISCUSSION AND CONCLUSIONS

The lowest of the three herbicide rates used for each herbicide treatment was too low for adequate weed control. The highest of the three rates normally would be excessive. Under certain conditions, such as high temperature and dry soil, dichlobenil may volatilize, limiting effective weed control to about 2 months, thus allowing weed invasion for much of the growing season.

Many plant species are susceptible to chemical damage when very young, but are usually more tolerant of the same chemicals during the second or third growing seasons. Therefore, some of the species damaged by the herbicide treatments used in this study may show greater tolerance if the herbicide is applied after the first growing season. However, if herbicides are not used until the second year, weeds should be controlled by cultivation the first year.

Some species are much more susceptible to herbicide damage than others. Neither black walnut nor sweetgum survival was affected by any of the herbicide treatments and only the highest rate of dichlobenil killed white oak. Survival of sycamore and European alder was decreased substantially by all herbicide treatments except dichlobenil. Survival of black locust, white ash, and river birch was poorest when mixtures containing atrazine were used.

Cultivation produced better height growth for most species than any of the herbicide treatments. Neither the growth of black walnut nor white oak was affected, but first-year growth of these two species is characteristically poor. Cultivated yellow-poplar, sycamore, black locust, and white ash grew much better than their chemically treated counterparts. Mixtures containing atrazine were especially detrimental to growth of river birch, sycamore, and European alder; sweetgum seems sensitive to dichlobenil.

With the exception of the poor survival of European alder when the atrazine-simazine mixture was applied after planting, it made no difference whether herbicides were applied before or after planting. Erdmann (1967), although testing other species, stated that atrazine should be applied before planting to prevent injury.

Each species was tolerant of at least one of the herbicides tested. Cultivated trees grew faster than herbicide-treated trees the first growing season, but cultivation is expensive. These results indicate, however, that for maximum growth some species should be cultivated the first year, then compatible herbicides used the second and third years.

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