IMPACT OF CHEMICAL SITE PREPARATION ON SURVIVAL AND GROWTH OF FIVE HARDWOOD SPECIES[1]

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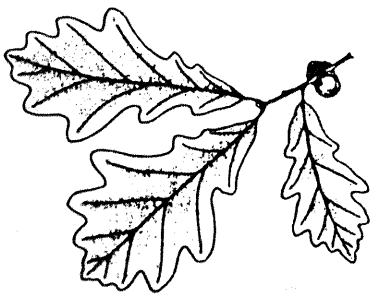

ABSTRACT.--Seven herbicides (dalapon, 2,4-D, simazine, sethoxydim, glyphosate, atrazine, and sulfometuron methyl) at various rates and combinations were evaluated five commercially valuable hardwood species (Juglans nigra L., Quercus rubra L., Quercus alba L., Fraxinus americana L., and Liriodendron tulipfera L.) planted into chemically site prepared abandoned field plots. The herbicide rates and combinations were selected based on their cost effectiveness, compatability with commercial hardwood species, and ability to control a variety of abandoned field weed species. Significant differences occurred between the different herbicide treatments. Weed control ranged from 47 (sethoxydim 0.3 kg/ha + simazine 3.4 kg/ha) to 92 percent (glyphosate 1.7 kg/ha + simazine 3.4 kg/ha + atrazine 2.2 kg/ha). Significant damage occurred to white ash at the higher triazine rates. Seedling survival was significantly affected only for yellow-poplar and black walnut. Growth rates were improved for several species and treatment combinations compared to the control, but growth rates of seedlings in the sulfometuron methyl (0.2 kg/ha) treatment indicated a slight phytotoxicity to all species.

INTRODUCTION

Over three million hardwood seedlings of commercially valuable species were planted by Indiana landowners in 1984 in woods openings, underplantings, and old field plantations. If reasonable success of the plantings is expected, cultural treatments such as weed control, protection, pruning, and release must occur.

Initially, weed control is the most important cultural need of newly planted seedlings. In addition to removing competition for moisture, nutrients, and light, many rodent problems will be reduced as cover is destroyed. The easiest and most effective way to control mixed weed populations is pre-plant with a good site preparation treatment. Broad spectrum or non-selective herbicides may be used at this time, or in combination with mowing or tillage without fear of crop tree damage from foliage contact.

The benefits of controlling grass and herbaceous vegetation before planting and during the early years are well documented for hardwood species (Sherrick, 1978; McCormack, 1981; Zutter, 1982; Burke and Williams 1973; Byrnes et al., 1973; Fitzgerald and Seldon, 1975). Differences in survival, height growth and levels of animal damage become even more apparent in the second growing season as competing vegetation overtops untreated plantations.

Maintaining good weed control is particularly important for many hardwood species, since initial height growth is slow. In particular, oaks tend to concentrate initial growth on the root system, often with negligible height increases. Plass and Green (1963) found that slow initial growth of white oak without weed control in southern Illinois old fields, resulted in dominance by native brush after five years.

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Numerous studies have identified chemical combinations for site preparation that are effective in controlling a broad spectrum of weeds, with residual control (Erdman, 1967; Shipman, 1975; von Althon, 1976; Holt and Maskal, 1983; Seifert et al., 1982). Fall or spring applications reduce weed competition during the most active period (May-June) of hardwood growth.. Follow-up with mowing to reduce the height of "escape" weeds and invading summer annuals will prepare the plantation for subsequent fall or spring maintenance applications. The rates of herbicides used in site preparation and maintenance cannot be expected to provide more than one growing season of weed control. Higher rates necessary for significant carry-over, would cause crop tree injury or mortality in many cases.

OBJECTIVES

The objectives of the study were to select cost effective herbicide combinations for site preparation that would control the broad spectrum of herbaceous and grassy vegetation found in old field situations and have low phytotoxicity to five commercially valuable hardwood species.

MATERIALS AND METHODS

The study was conducted at the Southern Indiana Purdue Agricultural Center on unglaciated sandstone-shale derived soils. The soils are representative of about 2.5 million hectares of upland forestland in Indiana. The soil type was a Zanesville silt-loam (Typic Fragiudalf, fine-silty), which occurs on broad, flat ridges. A fragipan typically occurs at depths of 46 - 74 cm.

Because of the level to gentle slopes, many of the Zanesville soils were cleared decades ago and placed in agricultural crop production. Today, erosion and slow spring drying (due to the perched water on the fragipan) have reduced the acreage of Zanesville soil in row crop production. Many of these soils are now used for pasture or are allowed to revert back to timber production. The study area was such an old field with a vegetative composition of mixed annual and perennial grasses, broadleaf weeds, and pioneer woody plant species. The white oak site index based on timber stands adjacent to the old field, was 21 meters (Carmean, 1971).

Experimental Design

The experimental design for the study was a split-plot arranged in a randomized complete block design. There were three replications, five plots (species), and ten subplots (herbicide treatments). Sixteen seedlings per species were planted in each of 150 1.5 x 3.0 m subplots for total of 2400 seedlings in the 1.4 ha study area.

Weed Composition

The predominate weed species on the study area at the time of the herbicide application were winter annuals, perennial grasses and broadleaf weeds, and woody perennials. Most abundant were: rough fleabane (Erigeron strigosus Muhl. ex Willd.), henbit (Lamium amplexicaule L.), tall fescue (Festuca arundinacea Schreb.), hemp dogbane (Apocynum cannabinum L.), gray goldenrod (Solidago nemoralis Ait.), oxeye daisy (Chrysanthemum leucanthemum L.), smooth sumac (Rhus glabra L.), poison-ivy (Rhus radicans L.), white ash (Fraxinus americana L.), slippery elm (Ulmus rubra Muhl.), sassafras (Sassafras albidum (Nutt.)) and yellow-poplar (Liriodendron tulipfera L.). Broomsedge (Andropogon virginicus L.) was also present but was just beginning to initiate leaf expansion. Most of the woody perennials had broken bud, but had not yet achieved full leaf expansion by the application date. The study area had been mowed the previous fall so the woody perennials were all sprouts or seedlings shorter than the 12 cm mowing height.

Herbicide Application

The herbicides were applied as a site preparation treatment on April 24, 1984 using a hand held CO_2 experimental plot sprayer with 3-Teejet 8002 flat-fan nozzles arranged in parallel orientation for a total swath width of 1.5 meters. All treatments used a water carrier and were applied at a 1.6 km/hr ground speed at 2109 g/cm^2 pressure for a total spray volume of 383 l/ha.

Commercial formulations of seven herbicides (Table 1) were applied at various rates and combinations (see Table 3).

TABLE 1. Herbicides evaluated for hardwood seedling establishment.

Product	Manufacturer	Active Ingredients	Amount of a.i. in Formulation
Dowpon M	Dow	dalapon	74%
Esteron 99	Dow	2,4-D	0.45 kg/l
Princep 4L	Ciba-Geigy	simazine	0.48 kg/l
Aatrex 4L	Ciba-Geigy	atrazine	0.48 kg/l
Roundup	Monsanto	glyphosate	0.48 kg/l
Poast	BASF	sethoxydim	0.18 kg/l
Oust	Dupont	sulfometuron methyl	75%

Several simazine and simazine + atrazine treatment rates were applied to determine if adequate weed control could be obtained at lower rates without damage to triazine sensitive white ash. All treatment rates are expressed in kilograms of active ingredient per hectare.

Visual weed control ratings were made on June 13, 1984, 50 days after treatment (DAT). Control of broadleaf weeds and grasses was assessed independently and the composition of weed species remaining and/or invading species was recorded.

Planting Stock

The five hardwood species planted in this study were northern red oak (*Quercus rubra* L.), white oak (*Quercus alba* L.), white ash (*Fraxinus americana* L.), yellow-poplar (*Liriodendron tulipfera* L.) and black walnut (*Juglans nigra* L.). The stock was obtained from the state nursery as 1-0 seedlings. Seedlings were graded to provide uniformity in height and diameter within each species (Table 2). The seedlings were planted into the chemically site prepared subplots May 10-15, 1984 on a 1 x 0.3 m spacing using a planting hoe.

TABLE 2. Mean initial height of outplanted seedlings.

Species	Total Ht. (cm)
Northern red oak	32.4
White oak	22.2
White ash	30.4
Yellow-poplar	29.8
Black walnut	63.1

RESULTS

Weed Control

All of the herbicide combinations were designed to control a combination of broadleaf weeds and grasses with the exception of sethoxydim + simazine. For this reason, control of grass only for the sethoxydim + simazine treatment (59%) gives a better idea of the effectiveness of this treatment. Total weed control however, was only 47% (Table 3), and was the poorest of all other herbicide treatments. All herbicide treatments were significantly different from the control. The best weed control was obtained with combinations of glyphosate + the two higher rates of simazine, and with glyphosate + simazine + atrazine. Control was 93, 92, and 92 percent, respectively. In addition, dalapon + 2,4-D + simazine yielded excellent total weed control (86%). These treatments were not significantly different from each other using Duncan's New Multiple Range Test at $p < 0.05$. Glyphosate + the lowest rate of simazine, also yielded good weed control, 83%, but control was significantly less than treatments with the higher rates of simazine.

The two rates of sulfometuron methyl and sulfometuron methyl + simazine yielded good weed control (81, 73, and 76%, respectively), however these between treatment differences were not significant. Again, weed control for the sethoxydim + simazine, 47%, was significantly less than all other treatments except the control.

Chemical costs for treatments containing glyphosate were much higher than other treatments. However, in 3 of 4 treatments weed control was increased 6-45% by the addition of glyphosate. Increasing rates of simazine in the treatments with glyphosate yielded little improvement in weed control 50 DAT but probably improved residual weed control beyond 50 DAT.

Sulfometuron methyl was a very inexpensive treatment at the 0.1 and 0.2 kg/ha rates and produced satisfactory weed control (73 and 81%). Addition of simazine to sulfometuron methyl more than doubled the chemical costs while improving weed control by only 3%. Residual weed control did not appear to be improved beyond 50 DAT, so the addition of simazine did not appear to be necessary.

TABLE 3. Total weed control by treatment 50 days after herbicide application and chemical cost/ha for a broadcast application.

Herbicide Treatment	Rate 1/ (kg/ha)	Mean Weed Control %	Chemical Cost/ha
(1) Glyphosate + simazine	1.7 4.5	93 f 2/	$106 3/
(2) Glyphosate + simazine	1.7 3.4	92 f	99
(3) Glyphosate + simazine	1.7 2.2	83 de	90
(4) Glyphosate + simazine + atrazine	1.7 3.4 2.2	92 f	109
(5) Dalapon + 2,4-D ester + simazine	4.0 2.2 3.4	86 ef	67
(6) Sulfometuron methyl	0.2	81 cde	40
(7) Sulfometuron methyl	0.1	73 c	20
(8) Sulfometuron methyl + simazine	0.1 3.4	76 cd	44
(9) Sethoxydim + simazine	0.3 3.4	47 b	72
(10) Control	-	0 a	-

1/ All rates reflect amount of active ingredient per hectare.

2/ Numbers followed by the same letter between herbicide treatments are not significantly different ($p < 0.05$) based on Duncan's New Multiple Range Test.

3/ Retail chemical costs derived from an informal survey of local herbicide dealers.

The most cost effective treatment from the standpoint of adequate weed control (86%) and low cost/ha ($67) was the dalapon + 2,4-D + simazine treatment. The least cost effective treatment ($72) was sethoxydin + simazine yielding only 47% control. Applying these two products separately, though increasing labor and equipment costs, may significantly improve weed control and make it an effective treatment.

The most commonly occurring weed species present 50 DAT (Appendix A) was broomsedge, followed by hemp dogbane, tall fescue, persimmon, buckbrush, gray goldenrod, large crabgrass and trumpetcreeper. All are perennial species except large crabgrass, a summer annual. Broomsedge occurrence was much greater in treatments which did not receive glyphosate. Gray goldenrod was found only on the control and the sethoxydim + simazine treatment. Since sethoxydim is a highly selective grass herbicide it would not be expected to control gray goldenrod post-emergent. Large crabgrass, an invader species, occurred on all treatments except those that included sulfometuron methyl, and the sethoxydim + simazine treatment. Common ragweed was also conspicuously absent from treatments including sulfometuron methyl. As expected the control had the largest number of occurrences for most weed species. No other trends were apparent for the other commonly occurring species.

Survival

Survival was excellent for almost all species and treatment combinations, despite the relatively late planting time and dry conditions of the following summer. Northern red oak, white oak, and white ash survival ranged from 94-100% (Table 4) with no significant differences between herbicide treatments. Significant differences did occur for yellow-poplar. Weed control improved yellow-poplar survival for all treatments compared to the controls. Glyphosate + simazine (4.5 kg/ha) gave the best survival (98%), however was not significantly different from the next two highest treatments, sulfometuron methyl (0.1 kg/ha) (94%), and sethoxydim + simazine (92%). Black walnut survival also reflected significant differences, with treatments containing glyphosate + the two higher rates of simazine, and the control, yielding the highest survival rates (96, 96, and 98% respectively). Five treatments had survival rates significantly lower than the controls.

TABLE 4. First year survival for the five hardwood species by herbicide treatment.

Herbicide Treatment	First year survival by species				
	R Oak	W Oak	W Ash	Y-Pop	B Wal
			%		
(1)	94a[1/]	96a	100a	98d	96c
(2)	98a	94a	98a	90c	96c
(3)	100a	98a	100a	87bc	87b
(4)	98a	94a	98a	81b	94c
(5)	94a	98a	98a	81b	77a
(6)	96a	94a	96a	90c	85ab
(7)	96a	96a	98a	94cd	77a
(8)	98a	96a	96a	90c	85ab
(9)	100a	96a	98a	92cd	92bc
(10)	98a	98a	100a	71a	98c

1/ Numbers followed by the same letter between herbicide treatments are not significantly different ($p < 0.05$) based on Duncan's New Multiple Range Test.

Net Growth Increment

Northern red oak produced the largest net growth increments of all five species. However, only the low rate of sulfometuron methyl was significantly different form the controls, (9.4 cm vs. 12.8 cm, respectively) (Table 5). The higher rate of sulfometuron methyl produced a poorer net growth increment also (11.1 cm), but was not significant. The glyphosate + the two higher rates of simazine, dalapon + 2,4-D + simazine, and sethoxydim + simazine treatments all yielded significantly better growth increments than the sulfometuron methyl (0.1 kg/ha).

For white oak, the higher rate of sulfometuron methyl (0.2 kg/ha) yielded significantly poorer net growth increment (7.2 cm) than the controls (9.3 cm). The dalapon + 2,4-D + simazine treatment seedlings produced significantly better growth increments (10.5 cm) than any other treatment except the controls (9.3 cm).

White ash seedlings in four treatments: glyphosate + simazine (4.5 kg/ha) (9.6 cm), glyphosate + simazine + atrazine (9.0 cm), dalapon + 2,4-D + simazine (10.1 cm), and sulfometuron methyl + simazine (9.0 cm), provided significantly larger growth increments than the controls (6.1 cm).

Yellow-poplar is apparently the most sensitive to good weed control. The three best weed control treatments, glyphosate + the two higher rates of simazine (11.3 cm, 8.7 cm), and glyphosate + simazine + atrazine (9.9 cm) provided significantly better net growth increment than the control (5.8 cm).

TABLE 5. Mean net height growth increment of the five hardwood species by herbicide treatment.

Herbicide Treatment	First year height growth by species R Oak	W Oak	W Ash	Y-Pop	B Wal
			cm		
(1)	13.5b[1/]	7.5ab	9.6c	11.3e	5.5c
(2)	13.4b	8.1ab	6.6a	8.7cd	5.0bc
(3)	11.1ab	7.5ab	7.5ab	7.5bc	4.1ab
(4)	11.9ab	8.6ab	9.0bc	9.9de	4.1ab
(5)	12.5b	10.5c	10.1c	8.1bcd	4.5bc
(6)	11.1ab	7.2a	5.9a	4.7a	3.0a
(7)	9.4a	7.8ab	7.5ab	7.2bc	4.2ab
(8)	12.0ab	8.6ab	9.0bc	7.7bcd	4.7bc
(9)	12.8b	8.5ab	7.7ab	6.5abc	4.1ab
(10)	12.8b	9.3bc	6.1a	5.8ab	4.7bc

1/ Numbers followed by the same letter between herbicide treatments are not significantly different ($p < 0.05$) based on Duncan's New Multiple Range Test.

Black walnut exhibited the slowest growth rates of all five species despite the largest initial seedling size. The only treatment significantly different from the controls (4.7 cm) was sulfometuron methyl (02 kg/ha) at 3.0 cm. The glyphosate + simazine (4.5 kg/ha) net growth increments were larger than several other treatments, but the differences though significant, were small.

Two other trends are distinctly apparent when comparing net height growth increment by treatment for all five species: 1) the sulfometuron methyl (0.2 kg/ha) treatment yielded one of the two poorest net growth increments for all five species, and 2) the glyphosate + simazine (4.5 kg/ha) yielded one of the two best growth increments for all species except white oak.

Comparison of first year total height between species is not very useful at this time due to the wide variation in initial size of the planting stock.

Herbicide Damage to Crop Seedlings

Sensitivity of white ash to triazine herbicides was apparent in five of the seven treatments containing simazine or atrazine. The most damage occurred in the glyphosate + simazine + atrazine treatment, where 17% of the seedlings exhibited severe interveinal chlorsis and leaf curling. Twelve percent of white ash seedlings in the glyphosate + simazine (3.4 kg/ha) treatment were similarly affected, as well as 8% in the glyphosate + simazine (4.5 kg/ha) treatment, sethoxydim + simazine, and the glyphosate + simazine (2.2 kg/ha) treatments. No seedlings of the other four species were visibly damaged.

DISCUSSION

The herbicide treatment combinations were selected based on their compatability with hardwood species, relative cost effectiveness in a vegetation management system, and their suitability in providing satisfactory site preparation in an old field situation. Eight of the nine herbicide combinations evaluated were successful in providing control of herbaceous and grass vegetation (73 - 93%). Only sethoxydim + simazine failed to provide adequate control. Based on communication with a BASF representative, there may have been some antagonism between sethoxydim and simazine that reduced its activity.

Treatments containing glyphosate and the higher rates of simazine, though more costly, did provide better weed control (>90%) than all other treatments. The lower rates of sulfometuron methyl controlled grass and herbaceous vegetation but the rates were not high enough to control the woody perennials. This accounts for the lower weed control in the sulfometuron methyl treatments.

There is some growth reduction associated with the 0.2 kg/ha rate of sulfometuron methyl on all five species. When comparing survival of the black walnut seedlings, the treatments containing sulfometuron methyl and dalapon + 2,4-D + simazine treatments appear to have reduced survival. This sensitivity to sulfometuron methyl is also reflected in the growth rates of the black walnut and other species, but it is surprising to see sensitivity to the dalapon + 2,4-D + simazine treatment.

Yellow-poplar appears to be the most responsive of the five species to first year weed control, based on the increased survival of all chemical treatments over controls and improved growth rates for the three best weed control treatments. Natural yellow-poplar seedlings have also been shown to be responsive to vegetation management in the establishment stage (Beck and Della-Bianca, 1981).

Typically, improvements in first-year survival from chemical site preparation are modest (Sherrick, 1978). However, growth rates should be improved slightly, and distinct improvements should accompany both second year survival and net growth increment (Wright, et. al, 1984).

The key to survival and dominance of planted seedlings is rapid establishment and early growth. Most seedlings seem to fail at this stage. Their early growth rates are not adequate to compete with native vegetation. A number of factors affect the success of a planted tree including the seedling's physiologic condition, as well as the site preparation and planting quality. Uniformity of stock size used in this study, healthy appearance, and planting consistency insured that survival and growth parameters would be due primarily to the site preparation treatments.

Interveinal chlorosis and leaf curling occurred to occasional seedlings on all treatments containing triazine herbicides. A range of triazine rates (2.2 - 5.6 kg/ha) were tested to determine if acceptable weed control could be attained without damage, but with adequate weed control. While first year survival and net growth increments did not reflect it, damage occurred on all of these treatments. It is not known what effect the damage will have on survival and second year growth. Yellow-poplar also is suspected of being sensitive to triazine herbicides, however, no toxicity was noted in any of the treatments in this study.

Several weed species common on the study site did show a definite tolerance of most herbicide treatments. Species frequently having slight to no damage included: hemp dogbane, common and butterfly milkweed, trumpetcreeper, and buckbrush. Observations made 110 DAT indicated that many of the herbicide treatments had been heavily invaded by summer annuals, primarily foxtail (Setaria spp.), fall panicum (Panicum dichotomiflorum Michx.), and large crabgrass. The treatments containing sulfometuron methyl had the lower populations of the invader species, indicating better residual control with this product. This same effect was observed by Maskal et al., (unpublished data) when looking at weed control on reclaimed mineland.

CONCLUSIONS

Weed control using eight of the nine herbicide combinations was effective in reducing weed competition to acceptable levels (> 70% control) and are economical from the standpoint of initial chemical cost and reduction of mowing and cultivation expense. One factor not evaluated in this study, but which will probably become significant in year two is the reduction in animal damage that accompanies weed control.

White ash proved sensitive to all rates of simazine required to provide effective residual weed control. While damage was slight in all cases, effects on future survival and growth reductions are not known. For the oaks, yellow-poplar, and black walnut, combinations of non-selective and broadleaf selective herbicides appear to provide the best weed control, with no detrimental effects on seedling survival or growth. First year seedling survival is apparently not influenced by good weed control with the exception of yellow-poplar.

There appears to be some phytotoxicity associated with the higher rate of sulfometuron methyl application to all of the species tested in this study. Black walnut growth rates may have been further hampered by the fact that the Zanesville soil type is not a good black walnut site.

Because first year survival and growth rates are strongly influenced by seedling condition as well as site preparation and planting quality, interpretation of this first year growth data must be considered tentative.

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LITERATURE CITED

BECK, D. E. and L. DELLA-BIANCO. 1981. Yellow-Poplar: Characteristics and Management. USDA For. Serv. Ag. Hdbk. No. 583. 91 p.

BURKE, R. P. and R. D. WILLIAMS. 1973. Establishment and early culture of plantations. In: Black Walnut as a Crop. USDA For. Serv. Gen. Tech. Rep. NC-4. St. Paul, MN, pp. 36-41.

BYRNES, W. R., J. E. KRAJICEK and J. R. WICHMAN. 1973. Weed control. In: Black Walnut as a Crop. USDA For. Serv. Gen. Tech. Rep. NC-4. St. Paul, MN, pp. 42-48.

CARMEAN, W. H. 1971. Site index curves for black, white, scarlet and chestnut oaks in the Central States. USDA For. Serv. Res. Pap. NC-62, 8 p.

ERDMAN, G. G. 1967. Chemical weed control increases survival and growth in hardwood plantings. USDA For. Serv. Res. Note NC-34, 4 p.

FITZGERALD, C. H. and C. W. SELDON III. 1975. Herbaceous weed control accelerates growth in a young poplar plantation. J. For. 73(1):21-22.

HOLT, H. A. and M. J. MASKAL. 1983. 1983 Line-of-Road Herbicide Treatments. Dept. of For. and Nat. Res., Purdue Univ., 191 p.

MASKAL, M. J., H. A. HOLT and W. D. SCHRAND. Herbaceous weed control on reclaimed mineland. (Unpublished manuscript).

McCORMACK, M. L. 1981. Chemical weed control in Northeastern forests. Proc. 1981 John S. Wright For. Conf., Purdue Univ., W. Lafayette, IN, pp. 108-115.

PLASS, W. T. and A. W. GREEN. 1963. Preplanting treatments for brushy old fields in southern Illinois. USDA For. Serv. Res. Pap. CS-1, Columbus, OH, 8 p.

SEIFERT, J. R., G. M. WRIGHT, H. A. HOLT and B. C. FISCHER. 1982. Herbicide trials on white and Scotch pine. Proc. North Central Weed Control Conf., Indianapolis, IN, Vol. 37:129.

SHERRICK, S. L. 1978. Pre and post-emergent herbicide combinations for weed control in hardwood seedling establishment. Master's thesis, Purdue University, 69 p.

SHIPMAN, R. D. 1975. Preparing planting sites with herbicides. Tree Planter's Notes 26(1):1-4.

von ALTHON, F. W. 1976. Effects of site preparation and post-planting weed control on the survival and height growth of planted hardwood seedlings. Can. For. Serv. Rep. 0-X-248, Sault St. Marie, Ont., 15 pp.

WRIGHT, G. M., P. E. POPE, B. C. FISCHER, H. A. HOLT and W. R. BYRNES. 1984. Chemical weed control to establish natural and artificial oak regeneration in a mechanically thinned upland hardwood stand. Proc. So. Silv. Res. Conf., Atlanta, GA. (In Press).

ZUTTER, B. 1982. Hardwood plantation herbaceous weed control growth response studies. Auburn University Silvicultural Herbicide Cooperative Research Note No. 84-1. 11 p.

Appendix A. List of weed species present 50 days after herbicide application.

Scientific Name	Common Name
Ambrosia artemisiifolia L.	common ragweed
Andropogon virginicus L.	broomsedge
Apocynum cannabinum L.	hemp dogbane
Ascelepias syriaca L.	common milkweed
Asclepias tuberosa L.	butterfly milkweed
Campsis radicans (L.) Seem. ex Bureau	trumpetcreeper
Chrysamthemum leucanthemum L.	oxeye daisy
Conyza canadensis (L.) Cronq.	horseweed
Digitaria sanguinalis (L.) Scop.	large crabgrass
Diospyrus virginiana L.	persimmon
Erigeron strigosus Muhl. ex. Willd.	rough fleabane
Fraxinus americana L.	white ash
Festuca arundinacea Schreb.	tall fescue
Juniperus virginiana L.	eastern red cedar
Lespedeza cuneata (Dumont) G. Don	sericea lespedeza
Liquidambar styraciflua L.	sweetgum
Lolium perenne L.	perennial ryegrass
Plantago major L.	broadleaf plantain
Polygonum pennyslvanicum L.	Penn. smartweed
Potentilla recta L.	sulfur cinquefoil
Prunus serotina Ehrh.	black cherry
Rhus glabra L.	smooth sumac
Rhus radicans L.	poison-ivy
Rosa multiflora Thunb. ex Murr.	multiflora rose
Rumex crispus L.	curly dock
Sassafras albidum (Nutt.)	sassafras
Solanum carolinense L.	horsenettle
Solidago nemoralis Ait.	gray goldenrod
Symphoricarpos orbiculatus Moench.	buckbrush
Ulmus rubra Muhl.	slippery elm
Vernonia altissima (Nutt.)	tall ironweed
Vitis spp.	grapevine