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WOODY SPECIES SUSCEPTIBILITY TO FOREST HERBICIDES APPLIED BY GROUND MACHINES. J.H. Miller and M.B. Edwards, Southern Research Station, USDA Forest Service, Auburn Univ., AL, and Macon, GA.

ABSTRACT

This study used a simple approach of post-treatment observations to collect data on herbicide effectiveness for common southeastern hardwood and shrub species, and for loblolly pine. Both site preparation and release herbicides labeled for loblolly pine were examined. Blocked plots were established at seven locations on Central Georgia's Piedmont and coastal plains. All sites had been fuelwood harvested, affording abundant woody resprouts. Test herbicides were hexazinone (Velpar and Pronone), glyphosate (Roundup), imazapyr (Arsenal), triclopyr (Garlon), picloram (Tordon), and dicamba plus 2,4-D (Banvel or Vanquish). Most herbicides were applied singly at maximum labeled rates using tractor-mounted equipment. Site prep plots were prescribe burned after treatment. Percent of complete rootstock control for woody plants 3-10 ft tall is reported. Each herbicide had species that were effectively controlled, marginally controlled, and tolerant. Arsenal yielded the greatest control on the most species. Adding Escort (metsulfuron) to Roundup increased control of sweetgum, water oak, dogwood, winged elm, persimmon, and hawthorn. A calculation method for a control index is presented to aid prescription writing.

INTRODUCTION

Knowing how effective a herbicide is on a specific target species should be the basis for any herbicide prescription. However, reports of herbicide efficacy have been rare for the many southeastern hardwoods and shrubs (5, 6, 8, 13, 14, 15). Collection of efficacy information is both time consuming and costly, especially when documenting degrees of partial control. This is made more difficult in southern forestry because there are hundreds of competitive woody species (12). Fortunately, on most sites, two to ten species comprise the majority of target hardwoods, with two to eight infrequent associates (11). Because even small amounts of hardwood basal area results in greatly lowered pine growth (3), most hardwoods must be eliminated early if increased wood production is the management objective. Thus, the most effective prescription uses the most effective herbicide for the frequent species and another herbicide is often added to a tank-mix to control tolerant or less frequent species--relative to investment and ecological considerations.

This study used a simple approach of post-treatment observations to collect efficacy data. Reported here is the degree of "complete control" of common woody species using high rates of mostly singly applied herbicides. Knowing species control by single herbicides should assist in concocting logical tank mixes. Further, use of high rates assured that marginally-controlled and tolerant species were identified. Complete control was studied because it is easier to measure than partial control, which requires repeated measurements or estimates of crown reduction of tagged plants (10). Efficacy enhancement was examined with tank mixes. Also discussed is a procedure reported by Zedaker (16) whereby a control index can be calculated for comparing potential herbicide effectiveness for a specified stand composition.

METHODS

Two separate studies were installed in the Piedmont and coastal plains of central Georgia to evaluate herbicide treatments for site preparation and release of loblolly pine (Pinus taeda L.). Detailed methods of this research are in prior reports (1,9) and are only reviewed here. Residual hardwoods on all test sites had been harvested for fuelwood after commercial clearcutting, resulting in abundant, comparably-sized hardwood and shrub resprouts and seedlings. On site-preparation locations, harvesting had occurred at various times before treatment, from 2 months to 7 years. Release treatments were applied during the planted pine's third growing season, preceded only by a site-preparation burn before establishment.

In both studies, treatment plots were established using a randomized complete block design with one block at each location. Rectangular treatment plots averaged 1 and 1.8 acres, respectively, for site preparation and release. For studying efficacy, one Coastal Plain and two Piedmont blocks of the site-preparation study were sampled, as well as, two each Piedmont and Coastal Plain blocks of the release study. Surface soils of Piedmont sites were clay loam to sandy loam and Coastal Plain soils were loamy sands to sandy loams.

Six herbicide treatments were tested for pre-plant site preparation and four single herbicides and two mixtures were applied for over-the-top release (Table 1). High labeled rates were used, applied at label-recommended times. Site preparation treatments were applied in 1984, and release in 1985. Arsenal was not available for testing until 1985, when it was applied under an Experimental Use Permit at 1 quart per acre. This now exceeds the labeled rate for Arsenal release and is currently considered a site-preparation rate. Also, the glyphosate formulation presently labeled for southern forestry is Accord, which is comparable to the Roundup formulation tested here in concentration and therefore rate. Tordon 10K pellets are no longer manufactured, but the liquid formulation of picloram (Tordon K) is (picloram in Tordon K at 1.5 gal/acre equals Tordon 10K at 30 lb/acre). Herbicide-tolerant species may be similar for the two picloram formulations, but marginally controlled species may be different because of the foliar uptake as a liquid using Tordon K. Hexazinone rates (Pronone 10G and Velpar L) were prescribed according to soil texture and percent organic matter as specified on the labels. Thus, higher hexazinone rates were applied to Piedmont locations and lower rates to the Coastal Plain locations. Banvel is now Vanquish (dicamba).

Application equipment was mounted on crawler tractors. Sprays were applied using a Boomjet cluster nozzle (45-ft effective swath, with five nozzles, Spraying Systems Co., Wheaton. IL). Soil-active pellets were applied with an Omni air-blown spreader (85-ft effective swath, Renewed Resources Mfg. Co., Prattville, AL)(4, 7). Both systems had "application control systems" that maintained test rates as ground speed varied. Nozzle height was adjusted at each location to apply the liquid herbicide mixtures into the sides and over-the-top of most vegetation. The Omni spreader blew pellets up and into the swath pattern uniformly. Sprays were applied at 40 gal/acre total herbicide-water mixtures, except for Roundup which was applied at 25 gal/acre (per label instructions). A 5-ft swath overlap was used for site-preparation applications, while edge-to-edge swaths were used with release applications---assured by surveyed flagging stations. Treated vegetation on site-preparation plots was later prescribe burned in late October or early November, before planting to pine. Because of generally low fire intensities, woody plants were not completely consumed or controlled by the prescribe burns, which permitted the following examination of efficacy.

With both studies, individual hardwood and shrub species (Table 2) were examined in September and October of the growing season after the year of treatment (10). Three trained and experienced assessors walked into different plots at least 20 ft before starting their observations. They then examined the nearest hardwood or shrub that was 3 to 10 ft tall. Obvious skips, overlaps, and tractor damaged seedlings were avoided. No one assessor was restricted to evaluating a single herbicide on all sites to minimize this bias. Twigs and branches were broken to test for top kill along with observations on defoliation. Plants were recorded as "completely controlled" when all branches and the main stem were dead without any detectable resprouting, except with Arsenal treatments. Arsenal treated woody plants were recorded as completely controlled when completely defoliated and no malformed leaves were present, even when stems were flexible and green. (Varying degrees of regrowth have been noted for Arsenal- and Roundup-treated stems in the third year for plants with these symptoms (8).) After an observation was recorded, the assessor moved to the nearest woody plant for the next observation, and so on across the plots. Dead plants, especially winged sumac, that had already fallen, were examined and recorded in sequence.

The initial goal was to obtain observations on 20 plants per species per plot, but certain species were not present in that number on some plots and locations. With release treatments, observations were made on as many commonly occurring woody species as possible until 20 observation were gained on the infrequent species. This approach did not rely on pretreatment tagging, but on the assessor's ability to identify dead woody plants by twig, bark, and growth-form traits and to judge only complete mortality of the rootstock. Burning after site preparation treatments made identification more difficult but not impossible, which may not be possible for high intensity burns. Residual loblolly pines were examined in the same manner on site preparation plots, but pre-tagged measurement seedlings are reported for release mortality. Data from all observations for a species and herbicide were averaged for reporting.

RESULTS

Herbicide efficacy: The average complete control for specific species is presented in Table 3 for site-preparation applications (and burning) and Table 4 for release applications. The more effective herbicides for a species are apparent by examining these tables, as are herbicide tolerant species. For example, site-preparation applications on sweetgum with Roundup, Velpar, and Pronone were effective; Garlon and Banvel were marginal; and Tordon was ineffective. The higher site-preparation rates of Velpar, Pronone, and Roundup resulted in greater control of the same species than the lower release rates, except with black cherry and Velpar on loblolly pine. With site preparation, loblolly pine volunteers could be more effectively controlled by Garlon, Banvel, Tordon, and Roundup than by Velpar and Pronone. Tables 3 and 4 also show shrub control and tolerance, which should be useful depending upon prescription objectives because of their wildlife value.

Changes in efficacy with tank-mixing: Additions of Escort to Roundup appeared to enhance control of sweetgum, water oak, dogwood, winged elm, persimmon, hawthorn, and possibly sassafras and post oak (Table 5). The addition of 1 oz of Escort produced the most increase in control with these species, except persimmon and post oak, where control continued to increase with an additional ounce. No decreased control (or antagonism) was observed on the species tested with the Escort additions to Roundup. Results from the singly-applied herbicides should also suggest herbicide mixtures that could be tested for specific groups of species. It should be understood that some mixtures with Arsenal on sweetgum have been found to be antagonistic, resulting in less control with mixtures than with the single herbicide (2).

Control index calculations: The efficacy of complete control can be used to calculate a potential control index for evaluating treatment alternatives. The list of species and their percent composition in a stand (based on percent rootstock numbers or basal area) can be multiplied by the control values in Tables 3, 4 or 5 depending on treatment type. For example, calculations of a control index comparing Velpar L versus Garlon 4 for site preparation would be as follows for a stand with the following composition:

		Species Control		Control Index	
Species	Composition	Velpar	Garlon	Velpar	Garlon
sweetgum	50%	.84	.56	42	28
water oak	20%	.93	.55	19	11
blackgum	10%	.60	.54	6	5
black cherry	5%	.45	.53	7	3
hickory	5%	.30	.75	2	4
dogwood	5%	.63	.26	3	1
persimmon	5%	.17	.31	2	2
			INDEX	83	54

Thus, with this stand composition, Velpar is projected to provide 29 percent more complete control of these hardwoods than Garlon. Garlon mixed with Velpar may increase the control of hickory.

DISCUSSION

Information on complete control was gained more quickly by structuring and recording observations using a simple post-treatment procedure. To use this approach, assessors must be capable of identifying woody plants by twig, bark, and growth-form characteristics. Then determination of complete control in the year after treatment is fairly straightforward except with Arsenal. Thus, users could apply this method to gain information on efficacy on their own lands to assist in refining prescriptions and formulating promising tank mixtures. This method may not be usable on intensively burned site preparation areas. Little research has been done on species control as influenced by prescribe burning after broadcast herbicide application.

Herbicide efficacy is not constant but can vary considerably by the method of application, timing of application, the plant's physiological status, and the rate relative to plant size. With the interaction of these four factors, control on a particular species can vary from near 0 to 100 percent. The influence of these factors is complex and some general points are as follows:

Method of application--Equipment (aerial or ground); spray volume, surfactants, and droplet size; and granular concentration and size will affect effectiveness of a herbicide active-ingredient on different species.

Timing--Timing can be just as important as rate. The best strategy appears to select an optimum treatment date based upon the label information, recent research, and experience.

Plant status--Plant status also influences optimum timing. The main plant status of concern is low rainfall conditions that result in plant water stress. Water stress often decreases control because herbicide uptake and translocation is impaired. Plants should be actively growing and transpiring to optimize control. However, weather patterns of the southeastern forest region often necessitate applications during drought conditions, but these should be avoided if possible.

Rate--As far as effectiveness, higher rates usually result in greater control (15, 16). This was found when comparing species control using release versus site-preparation rates. As far as investment-return considerations, recent economic analyses show that the use of higher rates that result in greater control can yield enhanced returns (1).

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Table 1. Test herbicides, rates, and month of application.

Herbicides	Pounds of active ingredient (and product) per acre	Applied
Site Preparation		
Velpar L	2.5 to 3.5 hexazinone (1.25 to 1.75 gal)	May
Pronone 10G	2.5 to 3.5 hexazinone (25 to 35 lb)	May
Tordon 10K	3 picloram (30 lb)	June
Garlon 4	4 triclopyr (1 gal)	June
Banvel + Banvel 720	4 dicamba + 4 2,4-D (0.5 + 2 gal)	June
Roundup	4 glyphosate (1 gal)	August
Release		
Pronone 10G	0.9 to 1.5 hexazinone (9 to 15 lb)	April
Velpar L	1.0 to 2.25 hexazinone (2 to 4.5 qt)	May
Arsenal AC	1.0 imazapyr (1 qt)	June
Roundup	2.0 glyphosate (2 qt)	September
Roundup + Escort	1.5 glyphosate (1.5 qt) + 0.0375 and 0.075 metsulfuron (1 and 2 oz)	September

Table 2. Test species found on study sites.

Common Name	Scientific Name
American beautyberry	*Callicarpa americana* L.
Black cherry	*Prunus serotina* Ehrh.
Black tupelo (blackgum)	*Nyssa sylvatica* Marsh.
Blackjack oak	*Quercus marilandica* Muenchh.
Blueberry	*Vaccinium* spp.
Dogwood	*Cornus florida* L.
Hawthorn	*Crataegus* spp.
Hickory	*Carya* spp.
Loblolly pine	*Pinus taeda* L.
Persimmon	*Diospyros virginiana* L.
Plum	*Prunus* spp.
Post oak	*Quercus stellata* Wangenh.
Red maple	*Acer rubrum* L.
Sassafras	*Sassafras albidum* (Nutt.) Nees
Southern red oak	*Quercus falcata* Michx.
Sweetgum	*Liquidambar styraciflua* L.
Water oak	*Quercus nigra* L.
Waxmyrtle (southern bayberry)	*Myrica cerifera* L.
Winged elm	*Ulmus alata* Michx.
Winged sumac	*Rhus copallina* L.
Yellow poplar	*Liriodendron tulipifera* L.

Table 3. After site preparation applications (and prescribe burning), the percent of rootstocks completely controlled (and number examined in parenthesis) as assessed in September of the growing season after application.

Species	Velpar	Pronone	Roundup	Garlon	Tordon	Banvel +2,4-D
Trees						
Sweetgum	84 (61)	93 (60)	93 (60)	56 (61)	19 (64)	33 (59)
Water oak	93 (59)	91 (58)	75 (60)	55 (60)	50 (64)	15 (60)
Blackgum	60 (15)	73 (30)	54 (22)	37 (35)	14 (35)	85 (13)
Red maple	68 (31)	-[1]	- -	85 (21)	- -	36 (25)
Dogwood	63 (22)	28 (53)	66 (62)	26 (60)	31 (48)	44 (42)
Black cherry	45 (44)	64 (39)	75 (37)	53 (55)	79 (52)	27 (48)
Hickory	30 (20)	23 (22)	30 (20)	75 (20)	20 (20)	57 (21)
Yellow poplar	- -	0 (6)	- -	100 (7)	- -	- -
Winged elm	- -	83 (6)	89 (19)	100 (10)	- -	36 (22)
Persimmon	17 (39)	31 (41)	67 (33)	31 (16)	0 (32)	33 (12)
Loblolly pine[2]	12 (17)	0 (6)	84 (26)	100 (20)	95 (21)	97 (40)
Shrubs						
Blueberry	10 (22)	- -	67 (9)	17 (12)	- -	17 (46)
Hawthorn	45 (33)	100 (17)	- -	20 (15)	- -	20 (25)
Winged sumac	17 (40)	12 (8)	63 (35)	7 (59)	0 (20)	33 (6)
Beautyberry	0 (20)	0 (20)	- -	5 (20)	20 (10)	- -

[1]Species not present on treatment plots.
[2]Natural regeneration.

Table 4. After release applications, the percent of rootstocks completely controlled (and number examined in parenthesis) as assessed in September of the growing season after application.

Species	Velpar		Pronone		Roundup		Arsenal[1]	
Trees								
Sweetgum	68	(93)	48	(79)	47	(148)	96	(95)
Water oak	69	(67)	50	(32)	28	(97)	61	(78)
S. red oak	81	(48)	57	(37)	53	(90)	90	(69)
Blackgum	28	(60)	50	(8)	30	(64)	36	(22)
Red maple	35	(40)	0	(21)	67	(18)	68	(31)
Dogwood	6	(49)	9	(45)	12	(60)	23	(64)
Black cherry	52	(59)	24	(45)	92	(60)	60	(80)
Hickory	0	(24)	5	(20)	0	(23)	9	(21)
Winged elm	95	(21)	50	(20)	32	(22)	0	(37)
Persimmon	0	(55)	0	(43)	0	(32)	91	(22)
Blackjack oak	22	(18)	55	(20)	33	(21)	96	(23)
Sassafras	0	(20)	10	(48)	67	(42)	100	(23)
Loblolly pine[2]	45	(320)	26	(320)	17	(320)	13	(320)
Plum	90	(21)	-	-[3]	-	-	-	-
Shrubs								
Blueberry	-	-	0	(20)	-	-	-	-
Hawthorn	95	(20)	37	(43)	72	(25)	22	(55)
Winged sumac	77	(13)	32	(19)	78	(36)	100	(21)
Waxmyrtle	86	(21)	-	-	8	(13)	4	(25)

[1]A 1 quart (32 oz) per acre rate exceeds current label rates for release but not site preparation.
[2]Percent survival of 320 measurement pines at the end of the growing season of treatment.
[3]Species not present on treatment plots.

Table 5. After release applications, the percent of rootstocks completely controlled (and number examined in parenthesis) as assessed in September-October of the growing season after application.

Species	Roundup 2 qpa[1]	Roundup 1.5 qpa + Escort 1 opa[1]	Roundup 1.5 qpa + Escort 2 opa
Trees			
Sweetgum	47 (148)	69 (80)	71 (72)
Water oak	28 (97)	42 (80)	55 (31)
S. red oak	53 (90)	55 (42)	51 (47)
Dogwood	12 (60)	59 (54)	60 (43)
Black cherry	92 (60)	100 (20)	100 (16)
Hickory	0 (23)	0 (8)	0 (9)
Winged elm	32 (22)	94 (17)	100 (14)
Persimmon	0 (32)	15 (13)	36 (14)
Sassafras	67 (42)	92 (13)	84 (13)
Post oak	25 (4)	54 (24)	74 (19)
Shrubs			
Hawthorn	72 (25)	100 (20)	90 (11)
Winged sumac	78 (36)	68 (38)	95 (20)

[1]qpa= quarts per acre; opa= ounces per acre.