EFFECTS OF CHEMICAL SITE PREPARATION ON HERBACEOUS VEGETATION PRIOR TO HARDWOOD PLANTATION ESTABLISHMENT

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ABSTRACT

Chemical site preparation is sometimes prescribed when attempting hardwood afforestation in the South. However, adequate research has not been conducted regarding the efficacy of various herbicide treatments often recommended. For practical purposes, the question of whether chemical site preparation provides residual control of herbaceous vegetation in retired agricultural fields has not been answered. This study was performed near Port Barre, Louisiana. Four commonly used chemical site preparation treatments were applied during July 2004. Percent herbaceous coverage was estimated occularly May 2005 - August 2005. Herbaceous components were separated into grass/sedge or broadleaf categories and then further delineated into major species. Means separation was used to determine changes in herbaceous coverage percentages as the growing season progressed. Differences were found among average herbaceous coverage percentages among treatments and within individual treatments on a monthly basis. As the growing season progressed, an inverse relationship between grass/sedge and broadleaf categories was noted. Grass/sedge coverage decreased while broadleaf coverage increased in the treated areas.

INTRODUCTION

Government cost share programs, such as the Wetlands Reserve Program (WRP) and the Conservation Reserve Program (CRP), have increased public interest in afforestation of retired agricultural sites across the Lower Mississippi Alluvial Valley (LMAV). These programs offer financial incentives to aid in recovery of costs incurred by artificially regenerating forests (Schweitzer and Stanturf 1999). The vast majority of these lands are being afforested with hardwood species, and survival of planted hardwood seedlings has been very low in many of these areas (Schweitzer and others 1997). While seedling quality and planting quality are important considerations, the most influential factor in the failure of these plantings may be competing vegetation (Russell and others 1997). Both herbaceous and woody competition may pose a threat to seedling survival in afforestation attempts, with herbaceous competition posing the greater threat in the first years of establishment (Peltzer and Kochy 2001, Smith and others 1997). Increased growth and/or survival of hardwood plantings receiving herbicide treatments for competition control have been documented (Ezell and others 2007, Ezell and Catchot 1997, Ezell and Hodges 2002, Schuler and others 2005).

Many attempts have been made to reduce seedling mortality observed across the LMAV resulting from problems with competing vegetation. Some of these attempts have involved the use of chemical site preparation to achieve control of vegetation on sites where noxious species exist. However, land managers must consider that in highly productive areas, an extremely aggressive herbaceous weed complex can completely invade a site after effective chemical site preparation (Self and others 2010). When site conditions include more aggressive herbaceous complexes, a post plant growing season application using a broad spectrum herbaceous herbicide should be considered and utilized, if possible (Schuler and others 2005, Self and others 2010, Stanturf and others 2004).

In the past, some form of initial vegetation control was generally considered necessary on retired agricultural sites in the LMAV. These agricultural sites are invaded quickly by herbaceous species which decrease the amount of light and moisture available to seedlings (Gardiner and others 2002). Both mechanical and chemical treatments have been used in attempts to manage competing vegetation on these sites. However, due to increased fuel and labor costs, landowners may find chemical site preparation to be the more economical option. Many herbicidal compounds have been tested for use in site preparation. However, relatively few compounds are labeled for use in site preparation efforts for hardwood afforestation due to hardwood intolerance to herbicides commonly used in site preparation.

While imazapyr products are not typically used in established hardwood stands, several are sometimes used in chemical site preparation prior to hardwood afforestation. Non proprietary research testing the efficacy of imazapyr

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usage as a chemical site preparation compound in hardwood establishment is somewhat lacking. However, some studies have shown that if label rates for conifers are used and an adequate amount of time is allowed for compound breakdown, subsequent damage of hardwood seedlings is negligible or non existent (Schuler and others 2005, Yeiser 2003). At this study's initiation, Chopper®, Arsenal AC®, and OneStep® herbicides were the three most commonly encountered imazapyr products in forestry. For this reason, they were selected for application in this project. The objective of this study was to evaluate the efficacy of three chemical site preparation herbicides for providing residual control of herbaceous species during the growing season following application.

MATERIALS AND METHODS

SITE DESCRIPTION

The study area is located five miles northeast of Port Barre, Louisiana (30° 35' 15.19" N, - 91° 52' 41.88" W). The site was fallow for two years following extended soybean production. Watercourses border the site on all sides. The study area encompasses 80 acres within a 250 acre retired agricultural field. The soil is Sharkey clay (very fine, montmorillonitic, nonacid, thermic Vertic Haplaquepts), with slopes less than one percent. These soils are poorly drained and very slowly permeable. Average yearly temperature is 77.9 °F, and average yearly precipitation is 53.56 inches. Soil saturation was observed across the study area from January 2005 until early June 2005, but by October, cumulative precipitation was 16.58 inches lower than the yearly average for the area.

At the time of site selection and chemical site preparation application during July 2004, there was a well established and relatively even herbaceous groundcover with a scattered woody component. The entire research area was surveyed to determine initial herbaceous composition. Herbaceous coverage was estimated occularly and recorded by species and herbaceous categories (grass/sedge and broadleaf). Herbaceous species with coverage encompassing ten percent or more of the total area for any given treatment were designated as dominant species. Dominant herbaceous species onsite included: vaseygrass (Paspalum urvillei Steud.), sumpweed (Iva annua L.), Bermuda grass (Cynodon dactylon L.), beaked rush (Rhynchospora corniculata (Lam.) Gray), soft rush (Juncus effusus L.), curly dock (Rumex crispus L.), coffeeweed (Senna obtusifolia (L.) Irwin & Barneby), and Pennsylvania smartweed (Polygonum pensylvanicum L.). These species comprised approximately 95 percent of the herbaceous competition onsite. An additional 47 herbaceous species and seven woody species were present in small quantities, but did not comprise a significant component of the species complex.

STUDY DESIGN AND PLOT ESTABLISHMENT

A split plot design was used in this experiment. The research was conducted on a 72 acre rectangular area divided into three 24 acre replicates. Each replicate was split into four site preparation areas. Then each site preparation area was divided into four plots encompassing 1.5 acres each which served as the experimental units. All exterior and interior boundary lines were delineated using a transit and a 100 foot surveying tape. Plot corners were marked with five foot sections of one inch PVC pipe.

SITE PREPARATION TREATMENTS

Four chemical site preparation treatments were utilized in this study: (1) no herbicide application (untreated), (2) 32 ounces Chopper EC®/acre + one percent (v/v) Timbersurf 90®, (3) 16 ounces Arsenal AC®/acre + one percent (v/v) Timbersurf 90®, and (4) 16 ounces OneStep®/acre + one percent (v/v) Timbersurf 90®. These herbicides are commonly used at these rates for chemical site preparation and were applied using 20 gallons per acre total spray volume. Applications were completed using a cluster nozzle sprayer with a Radiarc® nozzle system and 0.048 tips mounted on an agricultural tractor. All chemical site preparation treatments were applied on July 26 and 27, 2004.

HERBACEOUS COVERAGE ESTIMATES

Herbaceous coverage estimates were recorded monthly from May 2005 through August 2005. Coverage percentage estimates were not completed during the month of September due to logistical complications arising from Hurricane Katrina. Percent ground cover of herbaceous categories (grass/sedge and broadleaves) was estimated occularly. Coverage percentages were recorded in one percent increments up to ten percent and in five percent intervals thereafter.

DATA ANALYSIS

Field coverage data were tested for normality and homogeneity of variances using univariate analysis in Statistical Analysis System (SAS) version 9.1®. Coverage percentages were arcsine square root transformed to normalize the data. However, actual means are presented in tables for ease of interpretation of percent change throughout the growing season. Analysis of variance was performed using PROC MIXED to test for main effects and to estimate least square means (LSMEANS) by treatment and among months by treatment. When main effects were significant, means separation was performed using Duncan's Multiple Range Test. Differences were considered significant at □ = 0.05.

RESULTS

PERCENT COVERAGE OF GRASS/SEDGE COMPONENT

Chemical site preparation treatments provided excellent initial herbaceous control in Chopper EC®, Arsenal AC®, and OneStep® treatment areas. Untreated areas retained the initial species complex comprised predominately of grasses/sedges through the end of the growing season. Herbaceous coverage in chemically treated areas ranged from zero to one percent from August 2004 through March 2005. In April 2005, a general estimate of herbaceous cover of between one and two percent with plants ranging between one and two inches in height was observed. Herbaceous coverage estimates were initiated May 2005.

The major grass species observed in all site preparation areas throughout the growing season were vaseygrass and bermudagrass. The most notable difference in May observations of grass/sedge coverage was found between chemical site preparation treatment areas and the untreated area (Table 1). There was greater coverage of grasses and sedges in the untreated area (97.0 percent) than in the Chopper EC®, Arsenal AC®, or OneStep® treatment areas (32.3 percent, 19.7 percent, and 16.0 percent, respectively). While lower than in the untreated area, grass/sedge coverage in Chopper EC® areas was greater than observed in Arsenal AC® and OneStep® areas. This pattern continued in June and July estimates. By August, grass/sedge coverage in the untreated area (90.0 percent) was greater than in the Chopper EC®, Arsenal AC®, and OneStep® treated areas (8.0 percent, 3.0 percent, and 2.3 percent, respectively). However, observed grass/sedge coverage in the chemical site preparation areas no longer differed.

Significant differences were observed within individual site preparation treatments from month to month (Table 1). Grass/sedge coverage in the untreated area did not differ from May to August (97.0 percent and 90.0 percent, respectively). Chopper EC® and Arsenal AC® grass/sedge coverage did not differ within treatment between May and June, but grass/sedge coverage for both treatments was lower in July and August. Observed grass/sedge coverage for the OneStep® treated area was lower in May than in June. July and August observations were the same (2.3 percent) and lower than those observed in May or June for the OneStep® site preparation area. Chemically treated areas exhibited August grass/sedge coverage estimates between 14.4 and 24.8 percent of those observed in May.

PERCENT COVERAGE OF BROADLEAF COMPONENT

Unlike grass/sedge coverage, broadleaf coverage was significantly lower in untreated areas than in any of the chemically treated areas (Table 2). The greatest broadleaf coverage in May was observed in Chopper EC® treatment areas (65.0 percent). Arsenal AC® and OneStep® areas exhibited similar broadleaf coverage (50.0 percent and 39.0 percent, respectively), but all were greater than the 7.3 percent coverage observed in the untreated areas. At this time, the major broadleaf competitor observed in all site preparation treatment areas was Pennsylvania smartweed. By June, broadleaf coverage in the Chopper EC® and Arsenal AC® areas was similar, and coverage in the Arsenal AC® areas was similar to the coverage in the OneStep® areas. The June broadleaf coverage estimate in the untreated area was lower than coverage in the three other treatment areas. The only major broadleaf species observed on site preparation treatment areas in June was still Pennsylvania smartweed.

By July, significant changes in percent broadleaf coverage were observed. At this point, a major influx of sumpweed, coffeeweed and Brazil vervain (Verbena brasiliensis Vell.) was observed with the established Pennsylvania smartweed across treated areas. July and August broadleaf coverage for the untreated area (53.3 percent and 50.0 percent, respectively) was roughly one half of the coverage observed in chemically treated areas (Table 2). Broadleaf coverage in the untreated area was lower than in any of the chemically treated areas for both months. None of the three chemical site preparation areas exhibited statistically different broadleaf coverage for the months of July or August.

Significant differences in broadleaf coverage were found within individual treatments on a monthly basis (Table 2). May broadleaf coverage observations for the three chemical site preparation treatments were lower than their corresponding estimates in June, July, or August. Observations in untreated areas differed in that May and June broadleaf coverage (7.3 percent and 13.3 percent, respectively) were not different. Both were lower than coverage estimates in July or August (53.3 percent and 50.0 percent, respectively). All treatment areas exhibited similar broadleaf coverage within their respective treatment during July and August. Each area exhibited broadleaf coverage greater than coverage estimates for May or June. By August, all site preparation treatment areas exhibited approximately two to seven times greater broadleaf coverage than observed in May.

TOTAL HERBACEOUS COVERAGE

By May, herbaceous plants (grasses/sedges and broadleaves) covered 104.3 percent of the untreated areas, with cumulative coverage in treated areas ranging from 55.0 percent to 97.3 percent (Table 3). Coverage increased in June and July, and by August, cumulative coverage in treated areas ranged from 100.0 percent to 108.0 percent compared to 140.0 percent in untreated areas. In essence, complete coverage was observed for all treatments with only the species composition varying by treatment. Chemical site preparation treatments did not provide long term residual control of herbaceous species on this site. The treatments merely shifted the species complex from a predominately grass/sedge coverage to one of broadleaves.

DISCUSSION

All site preparation treatments performed as expected. The Chopper EC®, Arsenal AC®, and OneStep® site preparation treatments provided excellent initial herbaceous and woody control. No significant changes were observed in the grass/sedge herbaceous component for the untreated areas from the time of treatment through the next growing season. The differential of grass coverage between treated and untreated areas demonstrated the efficacy of the herbicides on these species. However, grass/sedge coverage continued to decrease throughout the growing season in treated areas, indicating that the increase in the broadleaf component was limiting resources.

Broadleaf coverage increased across all treatments throughout the growing season. By August, chemically treated areas were observed to exhibit nearly complete vegetative coverage by broadleaf species. An important aspect of the broadleaf coverage in chemically treated areas was the existence of multiple canopies for different broadleaf species. For instance, in many areas both Pennsylvania smartweed and coffeeweed would exhibit coverage of 100 percent. In these situations coffeeweed would form a complete canopy ranging from six to nine feet in height and Pennsylvania smartweed would form an additional complete canopy ranging from two to three feet in height. Other broadleaf species were often intermixed within and between these canopies. This layering effect could severely impact the ability of planted seedlings to compete for the both light and soil moisture. Generally, in untreated areas, layering of grasses and sedges was not observed. In the few untreated areas that multiple canopies were observed, the layering effect did not appear to have a substantial impact on planted seedlings.

In this study, an inverse relationship between grass/sedge and broadleaf herbaceous components was observed. As grass/sedge coverage decreased, broadleaf coverage increased. Due to highly aggressive broadleaf species in the seedbed, nearly complete coverage of areas treated with chemical site preparation was observed by July. The lower broadleaf coverage observed in untreated areas was a result of established grass/sedge species maintaining coverage through July and August. Areas that received chemical treatment were relieved of the grass/sedge component and experienced significant increases of broadleaf encroachment compared to the untreated areas. By July, cumulative coverage of grass/sedge and broadleaf components was substantially greater in untreated areas compared to treated areas. However, the competitive nature of this coverage was reduced due to the greater percentage of the grass/sedge component in the species complex.

CONCLUSIONS

Interest in afforesting retired agricultural sites is increasing. Nearly 200,000 acres of retired agricultural fields were afforested during the 1990s (King and Keeland 1999). An additional 220,000 to 260,000 acres of retired fields were expected to be planted to forest by 2005, and over 30 million acres of retired agricultural fields are expected to be afforested by the year 2040 (Stanturf and others 1998, Wear and Greis 2002). Much of this acreage is expected to be regenerated with hardwood species.

Chemical site preparation should be used to control species which cannot be eliminated through the use of a post plant, broad spectrum, growing season herbicide application. Thus, when chemical treatment is deemed necessary to control existing onsite vegetation prior to planting, it should be part of an herbicide regime which includes a first growing season herbaceous weed control application. Additionally, with millions of acres of afforestation projected across the LMAV in the next few decades, the seriousness of aggressive herbaceous competition on retired agricultural sites can not be understated. Chemical site preparation is of limited efficacy on these plants, and disregarding this potential problem could have vast economical consequences. Of the three imazapyr formulations tested in this study, all provided excellent initial control of onsite herbaceous vegetation. However, by June broadleaf coverage had reached 65 percent or greater across all treatments. At the end of the growing season all treated areas were at or near 100 percent coverage. These increased levels of broadleaf coverage indicate an inadequacy of the initial chemical site preparation treatments in providing first growing season herbaceous control. Broadleaf coverage of this magnitude has been observed to significantly reduce seedling survival in comparison to areas of lower broadleaf and greater grass coverage (Self and others 2010).

If chemical site preparation is used as the only form of competition control on these sites, severe herbaceous competition can be expected by the following growing season. A post plant, pre emergence, broad spectrum herbicide application has the greatest potential to adequately control herbaceous vegetation on sites such as the one utilized in this study. Drawing from the authors experiences, if a late winter/early growing season broad spectrum herbicide application (i.e. 2 oz/acre Oust XP® in February or March) is used in conjunction with, or in place of, chemical site preparation chemical competition control will be practical and effective on most sites comparable to the test area.

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Table 1—Percent coverage of grass/sedge species by time of observation during the 2005 growing season

	Time of observation			
Treatment	May	June	July	August
	---------- ---percent----------			
Untreated	97.0a[1]A[2]	98.7aA	96.7aA	90.0aA
Chopper EC®	32.3bA	32.7bA	10.7bB	8.0bB
Arsenal AC®	19.7cA	22.3cA	3.3cB	3.0bB
OneStep®	16.0cB	25.0cA	2.3cC	2.3bC

[1]values followed by different lowercase letters within a column are significantly different at the α = 0.05 level according to Duncan's Multiple Range Test.

[2]values followed by different uppercase letters within a row are significantly different at the α = 0.05 level according to Duncan's Multiple Range Test.

Table 2—Percent coverage of broadleaf species by time of observation during the 2005 growing season

	Time of observation			
Treatment	May	June	July	August
	----------percent----------			
Untreated	7.3c[1]B[2]	13.3cB	53.3bA	50.0bA
Chopper EC®	65.0aC	85.0aB	95.0aA	100.0aA
Arsenal AC®	50.0bC	73.9abB	100.0aA	100.0aA
OneStep®	39.0bC	65.0bB	93.3aA	97.7aA

[1]values followed by different lowercase letters within a column are significantly different at the α = 0.05 level according to Duncan's Multiple Range Test.

[2]values followed by different uppercase letters within a row are significantly different at the α = 0.05 level according to Duncan's Multiple Range Test.

Table 3—Cumulative average coverage of herbaceous species* by time of observation during the 2005 growing season

	Time of observation			
Treatment	May	June	July	August
	----------percent----------			
Untreated	104.3	112.0	150.0	140.0
Chopper EC®	97.3	117.7	105.7	108.0
Arsenal AC®	69.7	96.2	103.3	103.0
OneStep®	55.0	90.0	95.6	100.0

*grass/sedge and broadleaf species combined