HERBICIDAL CONTROL OF *Lantana camara*

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ABSTRACT

Lantana is a perennial shrub that commonly infests pastures, roadsides, and natural areas. In Florida (USA), lantana flowers approximately 10 months of the year and is a prodigious seed producer. Though seed viability is reportedly low, lantana is most common in areas where birds roost: abandoned citrus groves, under power lines, along highway guard rails, etc. Many experiments have been conducted to manage this weed, but few successful herbicides have been found. In particular, foliar applications of triclopyr results in essentially no injury symptoms or reduction of lantana growth. However, little information is available for the effectiveness of fluroxypyr, aminopyralid, or aminocyclopyrachlor. Experiments were conducted in central Florida on a dense, natural infestation of lantana. Plots measured 8 meters by 16 meters and were replicated 4 times. Herbicides were applied in water at 230 L/ha. Aminopyralid (0.12 kg/ha), fluroxypyr (0.55 kg/ha), and aminocyclopyrachlor (0.2 kg/ha) were applied in the fall, approximately 2 months prior to frost. Half of the plots treated with each herbicide were re-treated the following spring (approximately 6 months later). Therefore, data consist of each herbicide applied in the fall alone as well as fall followed by spring. Aminopyralid was ineffective on lantana, either one or two applications resulted in <20% control one year after treatment (YAT). Fluroxypyr applied once resulted in 12% control at 1 YAT, but the two application treatment resulted in 80% control after one year. The combination of fluroxypyr + aminopyralid, applied twice, resulted in approximately 90% control 1 YAT. A single application of fluroxypyr + aminopyralid failed to provide greater than 20% control. Conversely, aminocyclopyrachlor applied once in the fall provided 98% lantana control at 1 YAT. Where aminocyclopyrachlor was applied twice, lantana control was 100%. From these data, lantana can be effectively controlled by two applications of fluroxypyr, two applications of fluroxypyr + aminopyralid, or a single application of aminocyclopyrachlor.

Keywords: Aminocyclopyrachlor, aminopyralid, basal, broadcast, cut surface, fluroxypyr.

INTRODUCTION

Lantana (*Lantana camara*) is an invasive exotic that is commonly found throughout the Southeast United States from Florida to Texas. Growing as either dense thickets or as individual plants,

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lantana can quickly dominate a landscape by out-competing native species (Day *et al.,* 2003). This species has been documented to grow best in recently disturbed sites (Thaman, 1974; Fensham *et al.,* 1994). For this reason, lantana is reaching epidemic levels in central Florida's abandoned citrus groves that have been renovated to pasture. Statewide, lantana is one of the top 10 most troublesome weeds in Florida and has been documented in 58 of 67 counties (USDA ARS, 2004).

The competitive and invasive nature of lantana stems from two primary defenses: allelopathy and resistance to herbivory. irst, allelochemicals produced in the roots and stems have been shown to negatively influence the growth and competitive ability of surrounding species and eventually to decrease biodiversity (Achhireddy and Singh, 1984; Achhireddy *et al.*, 1985; Foy and Inderjit, 2001). This allows for monotypic stands to readily develop, and, once established, it is highly persistent in the environment. Persistence of lantana is due to many factors, but one in particular is its resistance to herbivory due to toxin accumulation in the leaves (Ghisalberti, 2000). This, coupled with the fact that lantana can tolerate continual defoliation for 1 to 2 years (Winder, 1980; Broughton, 1999a), has greatly hampered the development of a biocontrol program (Broughton, 2000; Baars, 2003).

Lantana is considered one of the 10 most toxic weeds in the world (Sharma *et al.*, 1988). Ingesting approximately 3 mg of dry leaves per kg of body weight is a toxic dose for ruminant animals (Ghisaberti, 2000). Foraging of lantana by large animals can result in either acute (death within 12 to 24 hours) or chronic poisoning with the common symptoms of skin cracking and peeling (Knight and Walter, 2001). Regardless of quantity eaten, cattle that show symptoms of lantana toxicity rarely recover and resume productive gains (Seawright, 1963). The cattle industry is an important component of Southeast agriculture and it is critical to develop economically viable and sustainable control methods to prevent losses due to lantana.

Herbicidal control of lantana has been variable and difficult to achieve. The variability in control has been attributed to the fact that over 650 cultivars of lantana are known (Graaf, 1986). Regardless of cultivar, most researchers have examined the efficacy of 2,4-D, glyphosate, and triclopyr. Glyphosate, though quite consistent (Toth and Smith, 1984; Graaff, 1986; Erasmus and Clayton, 1992), is undesirable due to the non-target damage that is typical of its non-selective activity. In Florida, two commonly used pasture herbicides are 2,4-D and triclopyr. This is troubling since 2,4-D has frequently been shown to be inconsistent (Bartholomew and Anderson, 1978; Singh *et al.,* 1997), while triclopyr has little or no activity on lantana

(Toth and Smith, 1984; Graaff, 1986). Therefore, it is important to test other herbicides that are safe on pasture grasses to determine if these possess activity on lantana. Aminopyralid is a herbicide with many structural and physical similarities to picloram (Fast *et al.,* 2010). Considering the broad-spectrum activity that picloram possesses against woody brush, it is necessary to determine if aminopyralid would likewise be effective against lantana. Additionally, aminocyclopyrachlor is a new auxin-mimic herbicide that is being tested for use on woody brush (Turner *et al.,* 2010). It is currently unknown if aminocyclopyrachlor possess activity against lantana. The objectives of this research were to 1) determine if foliar applied herbicides could effectively control lantana, and 2) determine if herbicides applied as a basal treatment to standing plants, or to cut surfaces, will result in plant death.

MATERIALS AND METHODS

Experiments were initiated in September 2007 in Pasco County, FL and repeated in September 2009 in Lake County, FL. Both locations were livestock pastures with a naturally occurring lantana infestation of approximately one plant per 3 m^2.

Herbicides were applied using an all-terrain vehicle mounted sprayer calibrated to deliver 230 L/ha. Plots were 8 m wide by 16 m long with a 5 m non-treated buffer maintained between each set of sprayed plots. The non-treated buffer was used to allow accurate evaluation of lantana control to account for the variable density across the experimental area. Non-ionic surfactant was added to each herbicide treatment at 0.25% v/v. The experimental design was a randomized complete block with either three or four replications.
Foliar application of herbicides was initiated in the fall, approximately two months prior to the first frost. Lantana plants were not mowed prior to foliar applications. Herbicide treatments in 2007 consisted of aminopyralid (0.12 kg/ha), aminopyralid + 2,4-D (0.12 + 1 kg/ha), fluroxypyr (0.56 kg/ha), and fluroxypyr + aminopyralid (0.56 + 0.12 kg/ha). Each of these herbicides were applied once in the fall, or sequentially as fall followed by an additional application in the spring. In 2009, all these herbicides were applied in a similar fashion to that in 2007, with the inclusion of aminocyclopyrachlor (0.21 kg/ha).

In a separate trial at each location in 2007 and 2009, herbicides mixed with basal oil were applied to individual plants. Triclopyr (20% solution), triclopyr + fluroxypyr (50% solution), triclopyr + aminopyralid (20 + 1%), and imazapyr (3%) were applied at a volume sufficient to cover the base of the plant and the surrounding stems. Additionally, another set of plants were clipped to a height of 10 cm and the herbicide/oil mixture was applied immediately to the cut surfaces. For these experiments, each treated plant was considered a replication and ten replications per treatment were used. Aminocyclopyrachlor was not incorporated into this study because an oil miscible formulation was not available.

Visual estimates were used to evaluate percent weed control using a scale of 0 to 100 where 0 = no control and 100 = complete control. Evaluations were conducted at 2, 6, and 12 months after the final herbicide application. All data were tested for main effects and interactions using ANOVA. Treatment means were separated using Fisher's Protected LSD Test at P=0.05.

RESULTS AND DISCUSSION

For experiments initiated in 2007, it was observed that neither aminopyralid nor aminopyralid + 2,4-D provided acceptable control at 12 months after treatment (MAT) (Table-1). At 2 and 6 MAT, the sequential treatments improved control by as much as 60%. However, both the single and sequential treatments provided less than 16% control at 12 MAT and no significant differences were observed. The application of fluroxypyr once in the fall resulted in control that was similar to the aminopyralid treatments. Though single fluroxypyr and fluroxypyr + aminopyralid application provided higher control initially, control did not differ from the single or sequential aminopyralid treatments by 12 MAT. Conversely, additional spring application of fluroxypyr or fluroxypyr + aminopyralid dramatically improved control over all other treatments. Fluroxypyr and fluroxypyr + aminopyralid provided 77 and 90% control, respectively at 12 MAT. No reports could be found that have documented the efficacy of aminopyralid or the impact of sequential applications on lantana control. Many reports have discussed the efficacy of 2,4-D (Singh *et al.,* 1997; Graaff, 1986), but at the rates tested in this trial, the low level of control was expected.

The results in 2009 were similar to those in 2007. Aminopyralid (single and sequential), aminopyralid + 2,4-D (single and sequential), fluroxypyr (single), fluroxypyr + aminopyralid (single) all provided less than 35% control at 12 MAT (Table-2). Conversely, sequential applications of fluroxypyr and fluroxypyr + aminopyralid provided 80 and 93% control, respectively at 12 MAT. From these data it was observed that two applications of fluroxypyr are necessary if control is to approach acceptable levels. The addition of aminopyralid numerically improved control on both occasions, but was only statistically significant in 2009 at 12 MAT. Although fluroxypyr is effective, there are limitations to this program. First, two applications in close succession must be conducted. One application was shown to fail, while a fall followed by spring application was consistently successful. However, it is unknown if control from the sequential treatments will be adversely affected if the second application is delayed until summer or later. Secondly, the price of two applications of fluroxypyr + aminopyralid may likely be inhibitory for most ranchers. Currently, this treatment could cost as much as $100/ha, not considering the cost of application (Ferrell and MacDonald, 2010). Therefore, the efficacy of amino-cyclopyrachlor was explored. It was observed that both single and sequential applications of aminocyclopyrachlor at rates of 0.21 kg/ha provided greater than 96% control at 12 MAT. Previous research has shown this same level of control (Toth and Smith, 1984; Graaff, 1986), but it was generally with glyphosate which cannot be applied broadcast to pastures due to unacceptable levels of grass injury. Conversely, aminocyclopyrachlor has been shown to be safe on numerous grass species (Enloe *et al.,* 2010; Rhodes, 2010). Although hundreds of lantana cultivars have been described and implicated as a reason for inconsistent herbicide control (Graaff, 1986), the efficacy of aminocyclopyrachlor was striking. We cannot, from these data, draw sweeping conclusions about the efficacy of aminocyclopyrachlor on all lantana biotypes. However, aminocyclopyrachlor was greatly superior to all other treatments tested and additional research on geographically distinct populations is warranted.

Table-1. Control of Lantana from foliar broadcast applications. Applications were applied in Fall 2007 and Spring 2008.

Herbicide	Timing	Rate (kg/ha)	2 MAT[1]	6 MAT	12 MAT
			---------------% control[2]---------------		
Aminopyralid	Fall	0.12	8 f	6 e	0 c
Aminopyralid	Fall + Spring	0.12	36 e	25 d	16 bc
Aminopyralid + 2,4-D	Fall	0.12 + 1	23 ef	0 e	6 bc
Aminopyralid + 2,4-D	Fall + Spring	0.12 + 1	43 de	60c	0 c
Fluroxypyr	Fall	0.56	68 bc	65 bc	12 bc
Fluroxypyr	Fall + Spring	0.56	86 ab	80 ab	77 a
Fluroxypyr + aminopyralid	Fall	0.56 + 0.12	63 cd	53 c	20 b
Fluroxypyr + aminopyralid	Fall + Spring	0.56 + 0.12	97 a	95a	90 a

[1] MAT – Months after treatment.
[2] Means followed by similar letters do not differ at P=0.05 level of significance.

Table-2. Control of lantana from foliar broadcast applications. Applications were applied in Fall 2009 and Spring 2010.

Herbicide	Timing	Rate (kg/ha)	2 MAT[1]	6 MAT	12 MAT
			----------% control[2]-------		
Aminopyralid	Fall	0.12	10 d	0 c	0 e
Aminopyralid	Fall + Spring	0.12	15 c	12 c	20 d
Aminopyralid + 2,4-D	Fall	0.12 + 1	5 d	5 c	9 de
Aminopyralid + 2,4-D	Fall + Spring	0.12 + 1	70 b	65 b	35 c
Fluroxypyr	Fall	0.56	72 b	12 c	12 de
Fluroxypyr	Fall + Spring	0.56	92 a	93 a	80 b
Fluroxypyr + aminopyralid	Fall	0.56 + 0.12	92 a	5 c	10 de
Fluroxypyr + aminopyralid	Fall + Spring	0.56 + 0.12	95 a	97 a	93 a
Aminocyclopyrachlor	Fall	0.21	47 c	96 a	96 a
Aminocyclopyrachlor	Fall + Spring	0.21	98 a	99 a	100 a

[1] MAT – Months after treatment.
[2] Means followed by similar letters do not differ at P=0.05 level of significance.

Experiments were also conducted to evaluate the efficacy of herbicides diluted in oil carrier applied directly to lantana stems, or freshly cut stem surfaces. Imazapyr was observed to provide excellent control at 6 MAT, but declined to 30% for basal applications and 70% for cut surface at 12 MAT (Table-3). Previous research has shown excellent control with imazapyr (Graaff, 1986). Although plants in the current experiments were defoliated and stunted by the application, full regrowth was observed in many of the treated plants. Control with triclopyr alone was poor. Though triclopyr was applied at rates much higher than in previous reports, the level of control was similar (Graaff, 1986). At 12 MAT, less than 27% control was observed when triclopyr was applied to stems or cut surfaces. However, the addition of fluroxypyr or aminopyralid greatly improved control over triclopyr alone. Therefore, if basal or cut surface applications are required, the addition of fluroxypyr or aminopyralid would be necessary to maximize control.

Table 3. Efficacy of herbicides applied to individual lantana plants as a cut-surface or basal application.

Herbicide[1]	Rate % v/v	Cut-surface		Basal	
		6 MAT[2]	12 MAT	6 MAT	12 MAT
	---------------% control[3]-----------				
Triclopyr	20	53 b	20 c	50 c	27 b
Triclopyr + fluroxypyr	50	95 a	95 a	82 b	80 a
Triclopyr + aminopyralid	20 + 1	90 a	95 a	50c	95 a
Imazapyr	3%	99 a	70 b	99 a	30 b

[1]Herbicides use rates were as follows: triclopyr (480 g /L), triclopyr + fluroxypyr (180 + 60 g /L), aminopyralid (240 /L), imazapyr (240 g /L).
[1] MAT – Months after treatment.
[2] Means followed by similar letters do not differ at P=0.05 level of significance.

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