HYBRID BERMUDAGRASS [*Cynodon dactylon* (L.) Pers.] TOLERANCE AND BROADLEAF WEED CONTROL USING TANK MIX COMBINATIONS OF DIFLUFENZOPYR

A Thesis

by

MATTHEW EDWARD MATOCHA

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2006

Major Subject: Agronomy

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Approved by:

Chair of Committee,	Paul A. Baumann
Committee Members,	Gaylon D. Morgan
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ABSTRACT

Hybrid Bermudagrass [*Cynodon dactylon* (L.) Pers.] Tolerance and Weed Control Using Tank Mix Combinations of Diflufenzopyr. (December 2006)

Matthew Edward Matocha, B.S., Texas A&M University

Chair of Advisory Committee: Dr. Paul A. Baumann

Field studies were conducted during the 2003 and 2004 growing seasons to: 1) evaluate the control of silverleaf nightshade and western ragweed, and (2) assess the forage tolerance of Coastal and Tifton 85 bermudagrass hybrids using tank mix combinations of diflufenzopyr. Herbicides that were evaluated in each study included picloram, multiple rates of picloram with diflufenzopyr, triclopyr, triclopyr with diflufenzopyr, dicamba + diflufenzopyr, and diflufenzopyr alone. Visual ratings were taken on the weed control experiments approximately 30, 60 and 90 days after treatment. Phytotoxicity ratings were taken prior to each harvest of the Coastal and Tifton 85 varieties to determine influence of each herbicide treatment. Each bermudagrass variety was harvested twice during each growing season to determine dry matter yield and quality. Forage quality, including crude protein, acid detergent fiber, and neutral detergent fiber, was assessed using near infrared reflectance spectroscopy.

Adding diflufenzopyr to triclopyr did not consistently increase control of silverleaf nightshade or western ragweed. In general, picloram + diflufenzopyr and picloram applied alone provided the greatest control of both species at the highest rate of picloram. Increased efficacy was more evident from the addition of diflufenzopyr to

picloram in 2004 on western ragweed. By the final ratings in both experimental years, dicamba + diflufenzopyr provided no more than 76% control of either species.

Both forage varieties showed significant variability in phytotoxicity between years. Although observed levels of growth reduction were relatively high at the first harvest in 2003, no treatment exceeded a 10% growth reduction by the second harvest for either forage variety. In addition, the only significant reduction in dry matter yield occurred at the first harvest of Coastal in 2003 from picloram + diflufenzopyr applied at the highest rate.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Forage grasses in Texas cover 22.4 million ha with 15.8% of this area (3.5 million ha) in bermudagrass [*Cynodon dactylon* (L.) Pers.] pastures for grazing and hay production (Smith and Anciso 2005). Bermudagrass acreage has increased dramatically since the development of hybrid bermudagrass at Tifton, GA in the 1940s (Hill et al. 2001). Coastal is the predominant hybrid bermudagrass variety across the state, however, newer varieties such as Tifton 85 provide superior yield and digestibility (Smith and Anciso 2005; Mandebvu et al. 1999).

Proper management of grazing and haying systems is crucial to providing sufficient quantity and quality of forage for livestock production. Both of these aspects of forage production are compromised from the presence of undesirable plant species that are either unpalatable or toxic to livestock (Stichler et al. 1998; Eleftherohorinos et al. 1993). Pasture weed management can be accomplished by maximizing the competitive ability of the forage crop through optimum fertilization, aeration, grazing management, and if possible, irrigation. However, at least 65% of the hay acreage in Texas has some type of herbicide applied for broadleaf or grass weed control (Smith and Anciso 2005).

Research continues to be conducted to expand chemical weed control options in an effort to counter the negative effects of weed species in forage systems. New

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This thesis follows the style and format of Weed Technology.

herbicide compounds must be thoroughly evaluated to assess their effectiveness and potential crop phytotoxicity before receiving a label.

Weed Control

Research has been conducted in an effort to control some of the most pernicious weeds in improved pastures and rangeland. The discovery and use of auxin-like herbicides was instrumental in laying the foundation for ‘present-day weed science’ (Troyer 2001). Many auxin-type herbicides have been registered for use since the 1940’s to reduce broadleaf weed competition and increase production of agronomic crops. Numerous compounds have been developed from chemical families such as the phenoxyacetic acids (phenoxys) and pyridinecarboxylic acids (pyridines). Herbicides in these families are similar in chemical structure to the endogenous plant growth hormone indole-3-acetic acid (IAA). When applied at low rates, these compounds behave like growth regulators within the plant. At high rates, however, they can have phytotoxic effects to susceptible broadleaf species (Vencill 2002).

The first phenoxy compound developed and used in both row crop and forage grass production was 2,4-D [dimethlyamine salt of (2,4-dichlorophenoxy)acetic acid] used for control of annual and perennial broadleaf weeds (Vencill 2002). The herbicide, 2,4-D, is the most widely used pasture herbicide because it is relatively inexpensive and provides broad spectrum weed control. However, mixtures of 2,4-D and other auxin-like compounds, such as picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) and dicamba (3,6-dichloro-2-methoxybenzoic acid), enhance the spectrum of weeds controlled and soil residual activity. Tough to control woody species are often treated with pyridines such as triclopyr [[(3,5,6-trichloro-2-pyridinyl)oxy] acetic acid], and clopyralid (3,6-dichloro-2- pyridinecarboxylic acid) (Bovey 2001; Vencill 2002; Koger et al. 1997).

In 1989, Sandoz Agro discovered a new class of chemistry known as the semicarbazones. One member of this family, diflufenzopyr (2-[1-[[[(3,5-difluorophenyl)amino]carbonyl]hydrazono]ethyl]-3-pyridinecarboxylic acid), synergistically promotes the activity of auxin herbicides (Grossmann et al. 2002). Diflufenzopyr is readily absorbed by roots and foliage and is xylem and phloem mobile. The mechanism of action of diflufenzopyr is the polar transport inhibition of indole-3-acetic acid (IAA) and synthetic auxin-like compounds, such as dicamba, in sensitive species. The presence of diflufenzopyr results in the abnormal accumulation of auxins in meristematic root and shoot regions and leads to growth inhibition, and eventual tissue decay (Vencill 2002; Grossman et al. 2002). Evidence of synergism provided by diflufenzopyr and auxin associations was demonstrated in a field experiment conducted conducted by Lym (1998). They evaluated dicamba (140 g a.e./ha), dicamba (196 g a.e./ha) plus the premix (1:2.5 ratio) of diflufenzopyr + dicamba (BAS-662: 107.8 g a.e./ ha), picloram (35 g a.e./ha), and picloram + BAS-662 (35 and 39.2 g a.e./ha) for control of Canada thistle (*Cirsium arvense* L.) and leafy spurge (*Euphorbia esula* L.). A dramatic increase in foliar injury (from 17 to 43%) to both species was observed at 1.5 months after treatment (MAT) when diflufenzopyr was included in a tank mix with dicamba or picloram. A greenhouse study conducted by Grossman et al. (2002) found that diflufenzopyr increased foliar uptake and translocation of dicamba in redroot pigweed (*Amaranthus retroflexus* L.) 16 hours after foliar treatment.

Infestations of herbaceous weeds, such as western ragweed (*Ambrosia psilostachya* DC.**)** can have detrimental effects on forage production and quality. Western ragweed is a competitive and perennial pasture weed found in both rangeland and improved pastureland. It reproduces both sexually and asexually and has no forage value (Bovey et al. 1966). Vermeire and Gillen (2000) reported data that suggests standing crops of western ragweed at 600 kg/ha can be tolerated before control should be considered. However, Reece et al. (2004) reported that seasonal grass production on the sandhills prairie was reduced by 21% when western ragweed herbage levels of 189 kg/ha were present following dry weather in the spring.

Research conducted by Bovey et al. (1966) found that annual applications with 2,4-D applied at 0.56, 1.12 and 2.24 kg a.e./ha, provided effective stand reductions of western ragweed one year after treatment (YAT). Plots were then retreated and similar results were obtained the following year. In contrast, Dahl et al. (1989) observed no significant reduction in western ragweed frequency over two consecutive years with 2,4-D applied at 0.28 and 0.56 kg a.e./ha. They also observed that triclopyr (0.28 kg a.e./ha) and dicamba + 2,4-D (0.07 and 0.21 kg a.e./ha) did not significantly reduce western ragweed frequency, but picloram (0.28 kg a.e./ha) did cause a significant reduction. Baumann and Smith (2000) reported over 95% control of western ragweed up to 119 days after treatment (DAT) with early postemergence (EPOST) applications of picloram

+ 2,4-D (0.54 and 0.71 kg a.e./ha), picloram (0.14 and 0.28 kg a.e./ha), and 2,4-D (1.12 kg a.e./ha).

Another potentially invasive, perennial, and toxic weed species in bermudagrass pastures is silverleaf nightshade (*Solanum elaeagnifolium* Cav.). Silverleaf nightshade propagates asexually through creeping rhizomes and root fragments, and sexually through the production of berries that are toxic to livestock (Bell et al. 1990; Boyd and Murray 1982; Boyd et al. 1984). Four separate studies conducted by Eleftherohorinos et al. (1993) evaluated both triclopyr and picloram at 1.5 and 3.0 kg ae/ha, and glyphosate at rates ranging from 2.7 to 7.2 kg/ha. They observed that triclopyr only provided less than 30% stem regrowth (23%) at the highest rate (3.0 kg a.e./ ha) in only one of the experiments. However, picloram provided less than 30% stem regrowth (0 to 29%) at both rates in all four experiments. Control with glyphosate was generally acceptable, however, glyphosate is not a viable option for silverleaf nightshade control in bermudagrass due to its high phytotoxicity.

Bermudagrass Tolerance

In addition to weed control, bermudagrass tolerance to herbicides is vitally important in any forage production system. Bovey et al. (1974) conducted field experiments on bermudagrass tolerance to several herbicides. They observed a significant decrease in common bermudagrass yields with picloram applied at 0.23, 0.45, 0.90, and 1.81 kg/ha. In addition, they also observed a significant reduction in Coastal dry matter yield with these same treatments. Smith (1993) reported reductions in Coastal bermudagrass yield from picloram + 2,4-D applied at 0.356 kg a.e./ha. Other bermudagrass hybrids, such as Hardie, have also shown significant reductions in dry matter yield when picloram + 2,4-D (0.16 and 0.56 kg a.e./ha), picloram + 2,4-D (0.22 and 0.84 kg a.e./ha), or 2,4-D + dicamba (1.26 and 0.42 kg a.e./ha) was applied (Koger et al. 1997).

The objectives of this research were to evaluate control of silverleaf nightshade and western ragweed from tank mix combinations of diflufenzopyr and other labeled herbicides. Secondly, to assess the forage tolerance of Coastal and Tifton 85 bermudagrass hybrids to these same treatments.

CHAPTER II

EFFECT OF DIFLUFENZOPYR TANK MIXES FOR CONTROL OF SILVERLEAF NIGHTSHADE (*Solanum elaeagnifolium* Cav.) AND WESTERN RAGWEED (*Ambrosia psilostachya* DC.)

Introduction

It is estimated that 42% of the total land area in the United states, or 400 million hectares, is used for pasture and grazing land (Bovey 1987). Much of this area was once dominated by perennial bunchgrasses. However, due to overgrazing by domestic livestock much of this area has been converted to annual grasslands that are susceptible to invasive dicots (DiTomaso 2000). Recently, losses from weeds in rangeland total more than all other pests combined with an estimated $2 billion in annual losses (DiTomaso 2000).

When rangeland or improved pastures are infested with weeds, they compete for the same environmental resources, such as light, water, and nutrients, that are limited in supply (Naylor 2002). If not properly managed, pernicious weed species will reduce yield and quality of desirable forage grasses for livestock. Whether in a grazing or haying system, weeds that are unpalatable or toxic to livestock can increase the costs associated with livestock production (DiTomaso 2000). Herbicide application to improved pastures and rangelands is often required to minimize the interference of weeds in order to maintain the production of high quality forage.

The use of herbicides has evolved substantially since the introduction of auxinic herbides in the 1940s. As reported in the literature, the use of 2,4-D on western ragweed has had varied results (Bovey et at. 1966; Dahl et al. 1989). However, 2,4-D combined with picloram provided effective control (Dahl et al. 1989). Compounds, such as diflufenzopyr, have been found to synergistically promote the herbicidal activity of other auxinic compounds (Grossmann et al. 2002). Therefore, these studies were conducted to assess the effectiveness of tank mix combinations of diflufenzopyr[1] for control of western ragweed and silverleaf nightshade.

Materials and Methods

Field experiments were conducted during the 2003 and 2004 growing seasons. Each study consisted of 19 herbicide treatments (Table 1) and was arranged in a randomized complete block design with three replications. The plot size was 3.05 m wide by 6.09 m long. Herbicide applications were made with a CO_2 backpack sprayer[2] equipped with 6 spray nozzles spaced 48.3 cm apart. The sprayer was calibrated to deliver 22.98 L ha using DG Teejet® 8003 VS flat-fan nozzles[3]. Herbicide applications were made postemergence (POST) to weed species that ranged from 20.3 to 30.5 cm in height. The herbicide treatments evaluated included diflufenzopyr (86.6% technical), Tordon®[4] 22K [picloram (0.24 kg a.e./L)], Remedy®[5] [triclopyr (0.36 kg a.e./L)], and Overdrive®[6] 70 DG [diflufenzopyr (0.09 kg a.e.) plus dicamba (0.23 kg a.e.). All treatments were applied at various rates either alone or in different combinations and are listed in Table 1. All treatments included a nonionic surfactant[7] applied at 0.25% (v/v)

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[1] Diflufenzopyr, BASF Co. Ag. Products, P.O. Box 13528, Research Triangle Park, NC 27709
[2] R & D Sprayers, 419 Hwy 104, Opelousas, LA 70570
[3] Spraying Systems Co., P.O. Box 7900, Wheaton, IL 60189
[4] Tordon® 22K, Dow AgroSciences, 9330 Zionsville Road, Indianapolis, IN 46268
[5] Remedy®, Dow AgroSciences, 9330 Zionsville Road, Indianapolis, IN 46268
[6] Overdrive®, BASF Co. Ag Products, P.O. Box 13528, Research Triangle Park, NC 27709
[7] SurfKing, Estes, Inc., P.O. Box 8287, Wichita Falls, TX 76307

Table 1. Herbicide treatments applied in weed control studies conducted in 2003 and 2004.

Herbicide	Rate kg a.e./ha
Picloram + Diflufenzopyr	0.07 + 0.028
Picloram + Diflufenzopyr	0.14 + 0.028
Picloram + Diflufenzopyr	0.14 + 0.056
Picloram + Diflufenzopyr	0.28 + 0.056
Picloram + Diflufenzopyr	0.28 + 0.112
Picloram + Diflufenzopyr	0.56 + 0.112
Triclopyr + Diflufenzopyr	0.21 + 0.028
Triclopyr + Diflufenzopyr	0.21 + 0.056
Overdrive®[a]	0.28
Overdrive®[b]	0.56
Picloram	0.07
Picloram	0.14
Picloram	0.28
Picloram	0.56
Triclopyr	0.21
Diflufenzopyr	0.028
Diflufenzopyr	0.056
Diflufenzopyr	0.112
Nontreated control	-

[a] Low rate recommended by BASF Corporation.
[b] High rate recommended by BASF Corporation.

and water was used as the spray carrier.

Visual ratings were taken on all weed control studies using a scale of 0 to 100%, where 0 represents no herbicidal effect and 100 represents total plant death. Each field study was evaluated approximately 30, 60 and 90 days after treatment (DAT).

All data were subjected to analyis of variance (ANOVA) using SPSS 11.0 for Windows[8]. Means were separated using Fisher's protected least significant difference (LSD) test at the significance level of 0.05. Year by treatment interactions were detected for both weed species evaluated. Therefore, the results are presented by experimental year.

Silverleaf Nightshade

The silverleaf nightshade field experiments were conducted at two different locations in 2003 and 2004. This was due to the considerable reduction in weed density following the first year's study. The 2003 study was located near Snook, TX, at the Texas Agricultural Experiment Station in eastern Burleson County (30 N 31' 56" x 96W 25' 17"). This site was a Ships-Weswood soil (Ships: Very-fine, mixed, active, thermic Chromic Hapluderts; Weswood: Fine-silty, mixed, superactive, thermic Udifluventic Haplustepts) with 1.4% organic matter and a pH of 7.8. The 2004 study was located near Rockdale, TX, in western Milam County (30 N 42' 13" x 97 W 6' 59"). The Milam County site was located on a Frio soil (Fine, smectitic, thermic Cumulic Haplustolls) with 4.27% organic matter and a pH of 7.5.

[8] SPSS, Inc., Headquarters, 233 S. Wacker Drive, 11th floor, Chicago, IL 60606

Western Ragweed

The western ragweed field experiments were conducted in western Grimes County, near Navasota, TX (30 N 25’ 40” x 95 W 59’ 38”), in 2003, and near Millican, TX, in southern Brazos County (30 N 25’ 28” x 096 W 15’ 31”) in 2004. The Grimes County experimental site was located on a Latium-Frelsburg soil (Latium: Fine, smectitic, thermic Udic Calciusterts; Frelsburg: Fine, smectitic, thermic Udic Calciusterts) with 1.9% organic matter and a pH of 8.1. The Brazos County site was located on a Gredge soil (Fine, smectitic, thermic Udic Paleustalfs) with 3.36% organic matter and a pH of 7.2.

Results and Discussion

Silverleaf Nightshade Control

In 2003, no significant differences were detected between all rates of picloram + diflufenzopyr, and picloram applied alone at any evaluation interval (28, 70, and 102 DAT) (Table 2). All rates of picloram + diflufenzopyr and picloram applied alone achieved greater than 98% control at 28 DAT. These treatments provided significantly greater control than triclopyr + diflufenzopyr (0.21 + 0.028 kg a.e./ha) (87%), triclopyr applied alone (81%), Overdrive® at both rates (86 and 87%, respectively), and diflufenzopyr applied alone at all rates (8, 10, and 8%, respectively) at 28 DAT. At 70 DAT, similar trends but reduced control was observed by all rates of picloram + diflufenzopyr (80 to 99%), and picloram at all rates applied alone (91 to 99%). A substantial increase in control (78 to 84%) was provided by all rates of diflufenzopyr applied alone at 70 DAT. However, diflufenzopyr applied alone (0.056 and 0.112 kg

Table 2. Effect of diflufenzopyr tank mixes on silverleaf nightshade control in 2003 and 2004.

Herbicide	Rate	2003 Rating (DAT)			2004 Rating (DAT)		
		28	70	102	32	60	92
	kg a.e./ha	%					
Picloram + Diflufenzopyr	0.07 + 0.028	99 a[a]	95 ab	93 a-d	82 cd	65 b-e	60 c-g
Picloram + Diflufenzopyr	0.14 + 0.028	100 a	80 a-d	95 abc	91 abc	75 abc	70 a-e
Picloram + Diflufenzopyr	0.14 + 0.056	100 a	92 abc	93 a-d	85 bc	68 bcd	65 b-f
Picloram + Diflufenzopyr	0.28 + 0.056	100 a	96 ab	97 ab	95 ab	75 abc	76 abc
Picloram + Diflufenzopyr	0.28 + 0.112	100 a	89 a-d	93 a-d	95 ab	80 abc	82 ab
Picloram + Diflufenzopyr	0.56 + 0.112	100 a	99 a	99 a	98 a	81 ab	71 a-d
Triclopyr + Diflufenzopyr	0.21 + 0.028	87 b	71 bcd	78 b-f	62 f	47 fg	53 d-h
Triclopyr + Diflufenzopyr	0.21 + 0.056	91 ab	77 a-d	82 a-e	62 f	37 gh	47 fgh
Overdrive®	0.28	86 b	64 d	68 ef	67 f	57 def	60 c-g
Overdrive®	0.56	87 b	67 d	74 def	68 ef	55 def	50 e-h

Table 2. Continued.

Herbicide	Rate	2003			2004		
		Rating (DAT)			Rating (DAT)		
		28	70	102	32	60	92
	kg a.e./ha	---			%---		
Picloram	0.07	100 a	91 abc	98 ab	71 def	55 def	57 c-g
Picloram	0.14	100 a	97 a	97 ab	81 cd	63 c-f	53 d-h
Picloram	0.28	100 a	91 abc	93 a-d	79cde	57 def	53 d-h
Picloram	0.56	100 a	99 a	100 a	98 a	86 a	87 a
Triclopyr	0.21	81 b	90 abc	95 ab	59 f	50 efg	48 fgh
Diflufenzopyr	0.028	8 c	84 a-d	84 a-e	17 g	27 h	43 gh
Diflufenzopyr	0.056	10 c	78 a-d	58 f	20 g	20 h	35 h
Diflufenzopyr	0.112	8 c	78 a-d	75 c-f	23 g	27 h	40 gh
Untreated	-	0 c	0 e	0 g	0 h	0 i	0 i

[a] Means within a column followed by the same letter are not significantly different (LSD, α = 0.05).

a.e./ha) resulted in diminished control (58 and 75%, respectively) at 102 DAT. Greater than 92% control was achieved by all rates and combinations of picloram + diflufenzopyr, picloram applied alone, and triclopyr applied alone at 102 DAT. Triclopyr + diflufenzopyr (0.21 + 0.028 kg a.e./ha) provided significantly less control (71 to 87%) than picloram + diflufenzopyr (0.56 + 0.112 kg a.e./ha) (99 to 100%) at all rating dates.

In 2004, greater than 81% control (82-98%) was provided by all rates of picloram + diflufenzopyr at 32 DAT. This efficacy level declined by 60 DAT where 65 to 81% control was observed. Picloram applied alone at all rates achieved from 71 to 98% control 32 DAT, but declined to 55 to 86% by 60 DAT. At all three rating dates (32, 60 and 92 DAT), less than 70% control was attained by both rates of triclopyr + diflufenzopyr, Overdrive®, triclopyr applied alone, and all rates of diflufenzopyr applied alone. By the final rating date (92 DAT), the treatments that provided 70% or greater control included picloram + diflufenzopyr (0.14 + 0.028, 0.28 + 0.056, 0.28 +0.112, and 0.56 + 0.112 kg a.e./ha), and picloram applied alone at 0.56 kg a.e./ha. In addition, picloram + diflufenzopyr applied at 0.28 + 0.056 and 0.28 + 0.112 kg a.e./ha, were the only two rates of this combination that provided significantly greater control (76 and 82%, respectively) than the corresponding rate of picloram applied alone (53%).

In general, levels of control in 2004 were reduced from that observed in 2003 for all treatments. For example, reduced levels of control (71 to 81%) were observed 32 DAT by picloram applied alone (0.07, 0.14, and 0.28 kg a.e./ha) when compared to the 100% control achieved at 28 DAT in the 2003 experiment. This may be attributed to differences in environmental conditions between the two years. During the month of study initiation, the 2004 experimental site received 37.3 mm less rainfall than the 2003 experimental site. For the duration of the evaluation period, the 2004 site received 47.8 mm less rainfall than the 2003 experimental site (Appendix A). The drier conditions experienced at the 2004 experimental site may have resulted in the plants growing less actively, therefore, resulting in less foliar uptake and translocation of herbicide.

Western Ragweed Control

At 30 DAT in 2003, treatments containing picloram + diflufenzopyr (0.28 + 0.112 and 0.56 + 0.112 kg a.e./ha) provided 70 and 85% control, respectively (Table 3). This level of control was comparable to picloram applied alone at 0.28 and 0.56 kg a.e./ ha (75 and 90%, respectively). Picloram applied alone (0.56 kg a.e. ha) and picloram + diflufenzopyr (0.56 + 0.112 kg a.e./ha) achieved significantly greater control (85 and 90%, respectively) than all other treatments 30 DAT. By 60 DAT, control provided by picloram + diflufenzopyr at the two highest rates (0.28 + 0.112 and 0.56 + 0.112 kg a.e./ ha), 90 and 95%, respectively, was not significantly different than picloram applied alone at the same rates (87 and 98%), but was significantly better than picloram + diflufenzopyr at the three lowest rates (59 to 73%). By 94 DAT, picloram + diflufenzopyr at the three highest rates provided significantly greater control (98, 97, and 98%, respectively) than picloram + diflufenzopyr at the lowest rate (72%). Triclopyr + diflufenzopyr was not more effective than triclopyr applied alone, achieving less than 63% control at all rates and rating dates. Diflufenzopyr applied alone provided significantly less control (12 to 32%) than picloram + diflufenzopyr at all rates and

Table 3. Effect of diflufenzopyr tank mixes on western ragweed control in 2003 and 2004.

Herbicide	Rate	2003			2004		
		Rating (DAT)			Rating (DAT)		
		30	60	94	32	63	95
	kg a.e./ha	---%					---
Picloram + Diflufenzopyr	0.07 + 0.028	55 de[a]	59 fg	72 cd	67 cde	63 de	67 ef
Picloram + Diflufenzopyr	0.14 + 0.028	65 c	73 de	87 abc	70 cd	74 cd	78 cde
Picloram + Diflufenzopyr	0.14 + 0.056	65 c	71 de	84 abc	72 bc	76 bcd	87 bc
Picloram + Diflufenzopyr	0.28 + 0.056	65 c	79 cd	98 a	80 ab	81 bc	95 ab
Picloram + Diflufenzopyr	0.28 + 0.112	70 bc	90 abc	97 a	72 bc	81 bc	97 ab
Picloram + Diflufenzopyr	0.56 + 0.112	85 a	95 ab	98 a	88 a	96 a	100 a
Triclopyr + Diflufenzopyr	0.21 + 0.028	47 ef	53 gh	62 de	43 g	50 f	52 h
Triclopyr + Diflufenzopyr	0.21 + 0.056	45 f	42 ij	57 e	45 g	50 f	50 h
Overdrive®	0.28	55 de	63 efg	72 cde	55 f	57 ef	60 fgh
Overdrive®	0.56	65 c	66 ef	76 cd	60 ef	65 de	70 def

Table 3. Continued.

Herbicide	Rate	2003			2004		
		Rating (DAT)			Rating (DAT)		
		30	60	94	32	63	95
	kg a.e./ha	---	---	---	%	---	---
Picloram	0.07	62 cd	63 efg	73 cd	43 g	48 f	53 gh
Picloram	0.14	63 cd	65 ef	82 bc	57 f	57 ef	65 fg
Picloram	0.28	75 b	87 bc	96 ab	62 def	67 de	81 cd
Picloram	0.56	90 a	98 a	99 a	73 bc	87 ab	96 ab
Triclopyr	0.21	47 ef	47 hi	62 de	32 h	33 g	20 i
Diflufenzopyr	0.028	20 g	18 k	32 f	20 i	22 gh	17 i
Diflufenzopyr	0.056	13 g	12 k	12 gh	13 i	10 hi	10 ij
Diflufenzopyr	0.112	20 g	33 j	27 fg	15 i	20 h	17 i
Untreated	-	0 h	0 l	0 h	0 j	0 i	0 j

[a] Means within a column followed by the same letter are not significantly different (LSD, α = 0.05).

across all evaluation intervals. Both rates of Overdrive provided below 77% control at all rating intervals in 2003.

In 2004, picloram + diflufenzopyr (0.56 + 0.112 kg a.e./ha) provided significantly greater control (88%) than all rates of picloram alone (43 to 73%), and all but one rate of picloram + diflufenzopyr (0.28 + 0.056 kg a.e./ha) which resulted in 80% control 32 DAT. Picloram + diflufenzopyr at (0.56 + 0.112 kg a.e./ha) provided significantly greater control (96%) than all other treatments 63 DAT, with the exception of picloram alone at the high rate (87%). By 95 DAT, picloram + diflufenzopyr at the three highest rates and the high rate of picloram alone provided 95 to 100% control of western ragweed. In 2004, no treatment containing of Overdrive®, triclopyr + diflufenzopyr, or diflufenzopyr alone provided over 70% control.

These data indicate that adding diflufenzopyr to triclopyr does not significantly change the level of control for silverleaf nightshade or western ragweed with one exception. In 2004, triclopyr + diflufenzopyr at both rates resulted in significantly greater control (43-52%) of western ragweed than triclopyr applied alone (20 to 33%). In general, picloram + diflufenzopyr and picloram applied alone provided the greatest control of both species at the highest rate of picloram. Eleftherohorinos et al. (1993) reported similar results where picloram alone provided effective control of silverleaf nightshade. In addition, Dahl et al. (1989) reported effective control of western ragweed with applications of picloram alone.

A significant increase in effectiveness of picloram due to the addition of diflufenzopyr was more evident in 2004 on western ragweed. This increase in control was observed across all rates and evaluation dates of this combination with only two exceptions. Picloram + diflufenzopyr at the highest rate did not provide significantly greater control than the equivalent rate of picloram applied alone when evaluated at 63 and 95 DAT. By the final rating in both years, Overdrive® provided no more than 76% control of either species. In addition, no treatment provided a significant reduction in stem regrowth when counts were taken between 10 and 13 MAT, with one exception. Picloram + diflufenzopyr (0.14 + 0.028 kg a.e./ha) significantly reduced stem regrowth of silverleaf nightshade in 2004, and western ragweed in 2003 when compared to the untreated (Appendix O).

A possible explanation for the differences observed in western ragweed control each year between picloram applied with or without diflufenzopyr may be the differences in rainfall during the evaluation period (Appendix B). The 2003 experimental site received 129.5 mm more precipitation than the 2004 site. In 2003, the more abundant rainfall provided more favorable growing conditions likely resulting in more similar activity of picloram whether applied alone or with diflufenzopyr. Although the 2004 site received considerably less rainfall which resulted in less favorable growing conditions, the addition of diflufenzopyr appeared to enhance the performance of picloram over picloram applied alone.

CHAPTER III

HYBRID BERMUDAGRASS TOLERANCE TO TANK MIXES OF DIFLUFENZOPYR

Introduction

Bermudagrass is a tenacious warm season perennial grass that represents one of the most important forage grasses in the southern United States (Gould 1978; Mitich 1989). It is highly resilient to grazing pressure and will thrive in either warm or hot weather, given adequate moisture and nutrients (Mitich 1989). It is well adapted to high clay content soils and bottomlands that are often subject to flooding and is also highly productive on moderately acid or alkaline soils that are well-drained (Mitich 1989; Gould 1978). One of the first hybrid varieties of bermudagrass developed and released in the 1940s for grazing and hay production was Coastal (Koger et al. 1997; Hill et al. 2001). Though numerous cultivars of bermudagrass are grown in the United States, Coastal continues to be the most widely used bermudagrass in forage production systems, with more than four million hectares grown from the Carolinas to California (Hill et al. 2001). Other hybrids have been developed over the last several decades for their increased yield, digestibility, cold tolerance, and faster curing time (Koger et al. 1997). A more recent release, Tifton 85, has been more productive in grazing trials, and has higher digestibility than either Coastal or other bermudagrass varieties (Burton 2001; Hill et al. 2001). Tifton 85 has wider leaves and thicker stems than Coastal is more productive during the establishment year (Hill et al. 2001). The use Tifton 85 has also been adopted in Brazil, Venezuela, Mexico, and other tropical countries (Hill et al. 2001).

The production of high-yielding, high quality forage is desirable in all forage systems. Proper management of forage systems often requires the use of herbicides to minimize the negative influence of weeds. Therefore, studies were conducted to determine the influence of several auxinic herbicides on forage yield and quality. These herbicide treatments (Table 4) were also used concurrently in efficacy studies on western ragweed and silverleaf nightshade.

Materials and Methods

Field experiments were conducted during the 2003 and 2004 growing seasons. The Coastal bermudagrass crop tolerance experimental site was located in western Lee County, near Lincoln, TX (30 N 16’ 20” x 96 W 58’ 34”), on a Crockett-Wilson soil (Crockett: Fine, smectitic, thermic Udertic Paleustalfs; Wilson: Fine, smectitic, thermic Oxyaquic Vertic Haplustalfs) with 1.5% organic matter and a pH of 5.2. The Tifton 85 bermudagrass crop tolerance experiment was conducted in Thrall, TX, in eastern Williamson County (30 N 35’ 30” x 97 W 17’ 44”), on a Burleson soil (Fine, smectitic, thermic Udic Haplusterts) with 1.6% organic matter and a pH of 7.1. Each experiment consisted of 19 treatments (Table 4) arranged in a randomized complete block design with four replications. Plot size was 2.44 by 6.09 m. Herbicide treatments were applied with a CO_2 backpack sprayer equipped with 5 nozzles spaced 48.3 cm apart. The sprayer was calibrated to deliver 30.6 L/ha of spray volume using DG Teejet® 8003 VS flat-fan nozzles. Herbicide treatments were applied POST to bermudagrass that was

Table 4. Herbicide treatments applied in the forage tolerance studies conducted in 2003 and 2004.

Herbicide	Rate kg a.e./ha
Picloram + Diflufenzopyr	0.07 + 0.028
Picloram + Diflufenzopyr	0.14 + 0.028
Picloram + Diflufenzopyr	0.14 + 0.056
Picloram + Diflufenzopyr	0.28 + 0.056
Picloram + Diflufenzopyr	0.28 + 0.112
Picloram + Diflufenzopyr	0.56 + 0.112
Triclopyr + Diflufenzopyr	0.21 + 0.028
Triclopyr + Diflufenzopyr	0.21 + 0.056
Overdrive®[a]	0.28
Overdrive®[b]	0.56
Picloram	0.07
Picloram	0.14
Picloram	0.28
Picloram	0.56
Triclopyr	0.21
Diflufenzopyr	0.028
Diflufenzopyr	0.056
Diflufenzopyr	0.112
Untreated Check	-

[a] Low rate recommended by BASF Corporation.
[b] High rate recommended by BASF Corporation.

10.2 to 25.4 cm in height. All herbicide treatments included a nonionic surfactant at 0.25% (v/v), and water was used as the spray carrier.

Visual assessment of forage injury from the herbicide treatments was evaluated prior to each harvest. Injury was assessed through visual ratings of growth reduction, necrosis, and chlorosis. Injury ratings were based on a scale of 0 to 100%, where 0 indicates no herbicide effect, and 100 represents total plant mortality. All treated plots were compared to an untreated plot in each replication. The bermudagrass tolerance experiments were harvested twice each season. The first harvest occurred approximately 2 to 6 weeks following POST applications. The second harvest was taken approximately 6 to 7 weeks following the first harvest. The harvest intervals were targeted to coincide with typical commercial harvest practices, and were subject to climatic conditions during the two years of the studies. At each harvest, a 1.01 by 6.1 m area from the middle of each plot was harvested with a Carter® flail harvester. The remaining forage was removed from the test area following harvest, and a broadcast application of 78.4 kg/ha of nitrogen (ammonium nitrate, 34-0-0) was applied to aid in bermudagrass regrowth for subsequent harvests.

During each harvest, fresh forage weights from the harvested area of each plot were recorded and a sub-sample was collected. Each sub-sample was weighed and oven dried at 65 C for 48 h. Sub-samples were then re-weighed and percent moisture content was calculated. Plot yields were calculated to determine dry matter yields (kg dm/ha). Each dried sub-sample was subjected to near infrared reflectance spectroscopy (NIRS) analysis to determine percent crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF).

All forage data was subjected to ANOVA using SPSS 11.0 for Windows. Means were separated using Fisher's protected least significant difference (LSD) test at the significance level of 0.05. No year by treatment interactions were detected for dry matter yield or crude protein; therefore, these data were combined over years. Interactions were observed for growth reduction in both varieties, so they are presented by year.

Results and Discussion

Coastal Bermudagrass Tolerance

Visual Injury. In 2003, visual growth reduction was observed prior to the first and second harvests. At the first harvest, growth reduction from picloram + diflufenzopyr at all rates and combinations ranged from 7.0 to 17.5% (Table 5). A significant increase in visual growth reduction was observed (16.3 and 17.5%) for picloram + diflufenzopyr (0.28 + 0.112 and 0.56 + 0.112 kg a.e./ha, respectively) when compared to picloram alone (0.28 and 0.56 kg a.e./ha) (5.0 and 8.8%, respectively). However, picloram + diflufenzopyr applied at these same rates resulted in growth reduction that was similar to equivalent rates (0.028 and 0.112 kg a.e./ha) of diflufenzopyr applied alone (11.3 and 18.8%). Differences in growth reduction between diflufenzopyr applied alone (0.028 kg a.e./ha) and picloram + diflufenzopyr (0.07 + 0.028 and 0.14 + 0.028 kg a.e./ha) were only numeric. The effect of triclopyr +

Table 5. Effect of diflufenzopyr tank mixes on Coastal bermudagrass growth reduction in 2003 and 2004.

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e./ha	-------------------------------------	%	-------------------------------------	
Picloram + Diflufenzopyr	0.07 + 0.028	7.5 def[a]	6.3 a-d	0.0 b	0.0 a
Picloram + Diflufenzopyr	0.14 + 0.028	7.0 def	6.3 a-d	0.0 b	0.0 a
Picloram + Diflufenzopyr	0.14 + 0.056	8.3 cde	8.8 ab	0.0 b	0.0 a
Picloram + Diflufenzopyr	0.28 + 0.056	11.3 a-d	10.0 a	0.0 b	0.0 a
Picloram + Diflufenzopyr	0.28 + 0.112	16.3 abc	6.3 a-d	0.0 b	0.0 a
Picloram + Diflufenzopyr	0.56 + 0.112	17.5 ab	3.8 b-e	0.0 b	0.0 a
Triclopyr + Diflufenzopyr	0.21 + 0.028	3.8 def	5.0 a-e	0.0 b	0.0 a
Triclopyr + Diflufenzopyr	0.21 + 0.056	6.3 def	7.5 abc	0.0 b	0.0 a
Overdrive®	0.28	2.5 ef	5.0 a-e	1.3 b	0.0 a
Overdrive®	0.56	5.0 def	3.8 b-e	0.0 b	0.0 a

Table 5. Continued.

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e./ha	---%			
Picloram	0.07	3.8 def	1.3 de	0.0 b	0.0 a
Picloram	0.14	9.5 b-e	5.0 a-e	0.0 b	0.0 a
Picloram	0.28	5.0 def	3.8 b-e	0.0 b	0.0 a
Picloram	0.56	8.8 cde	2.5 cde	0.0 b	0.0 a
Triclopyr	0.21	8.8 cde	6.3 a-d	0.0 b	0.0 a
Diflufenzopyr	0.028	0.0 f	0.0 e	0.0 b	0.0 a
Diflufenzopyr	0.056	11.3 a-d	1.3 de	0.0 b	0.0 a
Diflufenzopyr	0.112	18.8 a	6.3 a-d	0.0 b	0.0 a
Untreated	-	0.0 f	0.0 e	0.0 b	0.0 a

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

diflufenzopyr (both rates), triclopyr applied alone, and Overdrive®, on growth reduction was only numeric.

At the rating prior to the second harvest in 2003, picloram + diflufenzopyr at all rates reduced growth from 3.8 to 10%. The reduction in growth (10%) caused by picloram + diflufenzopyr (0.28 + 0.056 kg a.e. ha) was significantly greater than equivalent rates of picloram and diflufenzopyr applied alone (3.8 and 1.3%, respectively). The effect of triclopyr + diflufenzopyr (both rates) and Overdrive® (both rates) on growth reduction was similar to picloram applied alone (0.14, 0.28, and 0.56 kg a.e./ha), triclopyr applied alone (0.21 kg a.e./ha), and diflufenzopyr applied alone (0.056 and 0.112 kg a.e./ha).

In 2004, no significant growth reduction was observed. Overdrive® (0.28 kg a.e./ ha) showed a slight degree of growth reduction (less than 2%) at harvest one.

In 2003, minimal visual necrosis (less than 3%) was observed prior to harvest one, and none prior to harvest two. Similarly, less than 2% visual necrosis was observed prior to harvest one in 2004, and none prior to harvest two (Appendix E). Prior to harvest one in 2003, less than 1% of visual chlorosis was observed (Appendix F). No chlorosis was observed in 2004.

Dry Matter Yield. At harvest one, the tank-mixes of diflufenzopyr with picloram did not significantly influence dry matter yield when compared to corresponding rates of picloram alone (Table 6). However, picloram + diflufenzopyr (0.56 + 0.112 kg a.e./ha) yielded significantly less than the untreated. The treatments with picloram applied alone showed numerical decreases in dry matter yield as herbicide

Table 6. Effect of diflufenzopyr tank mixes on Coastal bermudagrass yield in 2003 and 2004.

Herbicide	Rate kg a.e./ha	2003 and 2004 Harvest 1	2003 and 2004 Harvest 2
		kg dry matter/ha	
Picloram + Diflufenzopyr	0.07 + 0.028	6575.0 a-d[a]	2275.3 ef
Picloram + Diflufenzopyr	0.14 + 0.028	6217.1 a-g	2042.9 f
Picloram + Diflufenzopyr	0.14 + 0.056	5618.6 b-g	2542.1 def
Picloram + Diflufenzopyr	0.28 + 0.056	5028.0 gh	2480.2 def
Picloram + Diflufenzopyr	0.28 + 0.112	5310.9 e-h	1999.2 f
Picloram + Diflufenzopyr	0.56 + 0.112	4125.6 h	2538.3 def
Triclopyr + Diflufenzopyr	0.21 + 0.028	5828.3 a-g	2510.5 def
Triclopyr + Diflufenzopyr	0.21 + 0.056	6286.7 a-f	3123.1 a-d
Overdrive®	0.28	6805.7 ab	2822.1 b-e
Overdrive®	0.56	6678.8 abc	2660.6 c-f
Picloram	0.07	6908.1 a	3248.3 abc
Picloram	0.14	5859.0 a-g	2967.2 a-e
Picloram	0.28	5461.3 d-g	3433.1 ab
Picloram	0.56	5297.2 e-h	3534.8 a
Triclopyr	0.21	6481.1 a-e	3136.4 a-d

Table 6. Continued.

Herbicide	Rate kg a.e./ha	2003 and 2004 Harvest 1	
		1	2
		kg dry matter/ha	
Diflufenzopyr	0.028	6105.7 a-g	3012.6 a-d
Diflufenzopyr	0.056	6109.9 a-g	2951.8 a-e
Diflufenzopyr	0.112	5181.2 fgh	3011.0 a-d
Untreated	-	5574.1 c-g	2619.3 c-f

[a] Means within a column followed by the same letter are not significantly different (LSD, α = 0.05).

rate increased. This trend, however, did not continue into the second harvest. The low rates of Overdrive® and picloram applied alone resulted in significant increases in forage yield compared to the untreated. Dry matter yield differences at the first harvest were only numeric for triclopyr + diflufenzopyr, and Overdrive® at both rates. By the second harvest, all treatments achieved comparable dry matter yields with two exceptions; picloram applied alone (0.28 and 0.56 kg a.e./ha) produced significantly more dry matter yield than the untreated. These results are different from what was reported by Brooks (1997), where picloram applied alone resulted in numerically less dry matter forage than the untreated. In addition, Bovey et al. (1974) reported a significant reduction in Coastal dry matter yield with picloram applied alone.

Quality analysis of the forage samples was generally consistent with a few exceptions. At harvest one, analysis of crude protein content was similar across all treatments with one exception. Picloram + diflufenzopyr applied at the lowest rate showed a significant increase in crude protein when compared to the untreated (Appendix G). Similar results were observed at harvest two across all treatments with one exception. Diflufenzopyr applied alone at the highest rate resulted in a significantly greater crude protein content when compared to the untreated (Appendix G). At harvest one in 2003, a significant decrease in acid detergent fiber and neutral detergent fiber was observed from picloram applied alone (0.14 kg a.e./ha) when compared to the untreated (Appendix H and I). In addition, diflufenzopyr applied alone (0.028 kg a.e./ha) showed a significant increase in neutral detergent fiber when compared to the untreated (Appendix I).

Tifton 85 Bermudagrass Tolerance

Visual Injury. In 2003, at harvest one, all treatments evaluated caused a significant reduction in growth (Table 7). Growth reduction across all herbicide treatments ranged from 10 to 66.3%. An increase in the degree of visual growth reduction as herbicide rate increased was evident. For example, all treatments of picloram + diflufenzopyr resulted in visual growth reduction ratings that ranged from 30% at the lowest herbicide rate, and up to 66.3% at the highest rate. Additionally, this combination caused significant reductions in growth when compared to corresponding rates of picloram applied alone that ranged from 12.5 to 23.8%. Also, all picloram + diflufenzopyr combinations resulted in significantly more growth reduction than all rates

Table 7. Effect of diflufenzopyr tank mixes on Tifton 85 bermudagrass growth reduction in 2003 and 2004.

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e./ha	%			
Picloram + Diflufenzopyr	0.07 + 0.028	30.0 de[a]	2.5 bc	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.14 + 0.028	40.0 c	1.3 c	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.14 + 0.056	41.3 c	2.5 bc	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.28 + 0.056	51.3 b	6.3 abc	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.28 + 0.112	57.5 b	2.5 bc	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.56 + 0.112	66.3 a	2.5 bc	0.0 a	0.0 a
Triclopyr + Diflufenzopyr	0.21 + 0.028	8.8 k	8.8 ab	0.0 a	0.0 a
Triclopyr + Diflufenzopyr	0.21 + 0.056	17.5 ghi	2.5 bc	0.0 a	0.0 a
Overdrive®	0.28	10.0 jk	3.8 abc	0.0 a	0.0 a
Overdrive®	0.56	13.8 ijk	1.3 c	0.0 a	0.0 a

Table 7. Continued.

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e./ha	-----%			-----
Picloram	0.07	12.5 ijk	5.0 abc	0.0 a	0.0 a
Picloram	0.14	16.3 hij	6.3 abc	0.0 a	0.0 a
Picloram	0.28	17.5 ghi	2.5 bc	0.0 a	0.0 a
Picloram	0.56	23.8 efg	5.0 abc	0.0 a	0.0 a
Triclopyr	0.21	17.5 ghi	10.0 a	0.0 a	0.0 a
Diflufenzopyr	0.028	21.3 fgh	0.0 c	0.0 a	0.0 a
Diflufenzopyr	0.056	27.5 ef	3.8 abc	0.0 a	0.0 a
Diflufenzopyr	0.112	35.0 cd	2.5 bc	0.0 a	0.0 a
Untreated	-	0.0 l	0.0 c	0.0 a	0.0 a

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

of triclopyr + diflufenzopyr, Overdrive®, and triclopyr applied alone. By the second harvest in 2003, growth reduction was substantially less evident across all treatments and rates and ranged from 0 to 10%.

In 2004, growth reduction was not observed in any of the treatments evaluated prior to harvest one or two. Additionally, a substantial amount of necrotic leaf injury to the Tifton 85 bermudagrass (Appendix J) was observed prior to harvest one in 2003; however, this injury did not translate into a significant yield reduction. In addition, visual chlorosis was not observed prior to either harvest in 2003 or 2004 (Appendix K).

Dry Matter Yield. At the first harvest, dry matter yields were not significantly different than the untreated across all but one treatment (Table 8). Picloram applied alone (0.28 kg a.e./ha) yielded significantly more dry matter forage than the untreated. All treatments containing picloram + diflufenzopyr and triclopyr applied alone yielded slightly less, though not significantly less, than the untreated. In addition, picloram + diflufenzopyr (0.14 + 0.056 and 0.028 + 0.056 kg a.e./ha) produced significantly less dry matter yield than picloram applied alone at 0.28 kg a.e./ha. In addition, the highest rate of picloram + diflufenzopyr (0.56 + 0.112 kg a.e./ha) yielded significantly less dry matter forage than picloram applied alone at the equivalent rate.

The second harvest yielded less forage across all treatments. Similar to the first harvest, dry matter yields between treatments containing picloram + diflufenzopyr were not significantly different. Unlike the first harvest, differences between all treatments

Table 8. Effect of diflufenzopyr tank mixes on Tifton 85 bermudagrass yield in 2003 and 2004.

Herbicide	Rate kg a.e./ha	2003 and 2004 Harvest 1	2003 and 2004 Harvest 2
		kg dry matter/ha	
Picloram + Diflufenzopyr	0.07 + 0.028	3865.2 c-f[a]	2769.1 abc
Picloram + Diflufenzopyr	0.14 + 0.028	3886.8 c-f	2783.7 abc
Picloram + Diflufenzopyr	0.14 + 0.056	3381.1 ef	2735.3 abc
Picloram + Diflufenzopyr	0.28 + 0.056	3729.2 def	2970.7 ab
Picloram + Diflufenzopyr	0.28 + 0.112	3711.6 def	3119.8 a
Picloram + Diflufenzopyr	0.56 + 0.112	3300.9 f	3003.7 ab
Triclopyr + Diflufenzopyr	0.21 + 0.028	4267.9 a-d	2512.9 bc
Triclopyr + Diflufenzopyr	0.21 + 0.056	4276.5 a-d	2598.2 abc
Overdrive®	0.28	4382.0 a-d	2512.3 bc
Overdrive®	0.56	4627.1 ab	2674.9 abc
Picloram	0.07	4055.4 b-e	2480.4 bcd
Picloram	0.14	4179.0 a-d	2681.9 abc
Picloram	0.28	4868.9 a	3083.7 a
Picloram	0.56	4041.6 b-e	2613.9 abc
Triclopyr	0.21	3866.9 c-f	1960.2 d

Table 8. Continued.

Herbicide	Rate kg a.e./ha	2003 and 2004 Harvest 1	2
		kg dry matter/ha	
Diflufenzopyr	0.028	4202.9 a-d	2672.5 abc
Diflufenzopyr	0.056	4551.7 abc	2966.6 ab
Diflufenzopyr	0.112	3883.5 c-f	2515.5 bc
Untreated	-	3914.3 b-f	2416.0 cd

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

consisting of either picloram + diflufenzopyr or picloram applied alone at equivalent rates were not significant. The three highest rates of picloram + diflufenzopyr, picloram applied alone (0.28 kg a.e./ha), and diflufenzopyr applied alone (0.56 kg a.e./ha), resulted in significantly greater dry matter yields than the untreated. These results are similar to what was reported by Brooks (1997), where picloram applied alone resulted in a significant dry matter yield reduction of Tifton 85 bermudagrass.

Analysis of forage acid detergent fiber and neutral detergent fiber was generally consistent with a few exceptions. Forage analysis indicated that picloram + diflufenzopyr applied at 0.14 + 0.028 kg a.e./ha caused an increase in acid detergent fiber at harvest one in 2003, when compared to the untreated (Appendix M).
At harvest one in 2004, an increase in acid detergent fiber was observed for Overdrive® at the high rate, when compared to the untreated (Appendice M).

In addition, picloram + diflufenzopyr (0.28 + 0.056 kg a.e./ha) caused a significant reduction in neutral detergent fiber, while an increase was observed from diflufenzopyr applied alone (0.112 kg a.e./ha) at harvest one in 2003 (Appendix N).

Growth reduction data for both forage varieties showed significant variability between years. Visual growth reduction ratings were higher in 2003 than 2004. This was likely due to more timely rainfall events received in 2004 (Appendix C and D). Although relatively high levels of growth reduction were observed at the first harvest in 2003, in the second harvest no treatment caused greater than 10% growth reduction for either forage variety. However, the only significant reduction in dry matter yield, when compared to the untreated, appeared in the first harvest of Coastal from picloram + diflufenzopyr applied at the highest rate.

Variation in precipitation between sites and among years may have contributed to some of the observed forage injury. In the three months preceding initiation of the Coastal bermudagrass tolerance studies, the 2003 site received approximately 86.4 mm precipitation, compared to 214.9 mm that was received in 2004. The precipitation received from study initiation to last harvest in 2004 (403.1 mm) was nearly twice of what was received in 2003 (224.5 mm) (Appendix C). Similarly, considerably more precipitation was observed at the Tifton 85 bermudagrass site in 2004 than in 2003. In the three months preceding study initiation, approximately 143 mm of precipitation was received in 2003 compared with 198.6 received in 2004. During the conduct of the study (study initiation to last harvest), 59.2 mm of precipitation was received in 2003 compared with 345.6 mm in 2004 (Appendix B). The increased precipitation in the months prior to and during the conduct of the studies in 2004 likely provided more moisture for favorable growing conditions which resulted in greater tolerance of the forage to herbicide application.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The field experiments evaluated the effectiveness of diflufenzopyr in tank mix with picloram, and triclopyr. In general, the highest rate of picloram + diflufenzopyr and picloram applied alone provided the greatest level of control of silverleaf nightshade and western ragweed. Picloram + diflufenzopyr applied at 0.28 + 0.056 and 0.28 + 0.112 kg a.e./ha, were the only two rates of this combination that provided significantly greater control of silverleaf nightshade than the corresponding rate of picloram applied alone. A significant increase in effectiveness of picloram due to the addition of diflufenzopyr was more evident in 2004 on western ragweed. This increase in control was observed across all rates and evaluation dates of this combination with only two exceptions. Picloram + diflufenzopyr at the highest rate did not provide significantly greater control than the equivalent rate of picloram applied alone when evaluated at 63 and 95 DAT. The data indicates that the addition of diflufenzopyr to triclopyr does not significantly increase control of silverleaf nightshade or western ragweed. In addition, Overdrive® provided no more than 76% control of either species by the final rating in both experimental years.

In the bermudagrass tolerance studies, growth reduction data for both forage varieties showed significant variability between years. Visual growth reduction ratings were higher in 2003 than 2004. This was likely due to more timely rainfall events received in 2004 that provided more moisture for favorable growing conditions which resulted in greater tolerance of the forage to herbicide application (Appendix C and D).

Although relatively high levels of growth reduction were observed at the first harvest in 2003, by the second harvest no treatment caused greater than 10% growth reduction for either forage species.

Yield data for coastal bermudagrass showed significant yield reduction at the first harvest for the high rate of picloram + diflufenzopyr, compared to the untreated. This yield reduction is likely due to the growth reduction observed in 2003. Similarly, the high rate of picloram + diflufenzopyr was the lowest yielding treatment on Tifton 85 at the first harvest, which follows the observed trend of increased growth reduction with increase of herbicide rate in 2003.

Due to the varied results in the aforementioned studies, more research should be conducted to further explore the tank mix effectiveness of diflufenzopyr.

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APPENDIX A

2003 AND 2004 PRECIPITATION DATA[a] FOR SILVERLEAF NIGHTSHADE EXPERIMENTAL SITES

Month	2003[b]	2004[b]
January	39.4	63.2
February	157.9	118.1
March	40.1	60.7
April	22.4	108.9
May	10.2	95.2
June	139.2	294.9
July	48	10.7
August	64	69.3
September	120.7	8.4
October	93	189.5
November	104	200.4
December	31	17.3
Total	869.9	1236.6

[a] Source: NCDC-NOAA (2003 and 2004).
[b] Data in mm.

APPENDIX B

2003 AND 2004 PRECIPITATION DATA[a] FOR WESTERN RAGWEED EXPERIMENTAL SITES

Month	2003[b]	2004[b]
January	20	115.3
February	96.3	150.1
March	27.2	70.6
April	14	106.7
May	14.7	198.4
June	94.7	298.5
July	69.6	59.2
August	44.7	63.5
September	160.8	6.6
October	80.5	96.8
November	111.3	234.2
December	50.8	27.2
Total	784.6	1427.1

[a] Source: NCDC-NOAA (2003 and 2004).
[b] Data in mm.

APPENDIX C

2003 AND 2004 PRECIPITATION DATA[a] FOR COASTAL BERMUDAGRASS EXPERIMENTAL SITE

Month	2003[b]	2004[b]
January	41.9	97
February	51.1	168.9
March	29.5	35.8
April	26.7	141.5
May	30.2	37.6
June	165.6	277.6
July	58.9	125.5
August	42.9	22.9
September	41.4	60.2
October	65.5	218.7
November	40.9	220.5
December	52.6	13.7
Total	647.2	1419.9

[a] Source: NCDC-NOAA (2003 and 2004).
[b] Data in mm.

APPENDIX D

2003 AND 2004 PRECIPITATION DATA[a] FOR TIFTON 85 BERMUDAGRASS EXPERIMENTAL SITE

Month	2003[b]	2004[b]
January	35.8	93.5
February	131.6	111.5
March	41.4	24.6
April	8.9	102.9
May	19.3	71.1
June	114.8	242.8
July	41.7	25.9
August	17.5	76.9
September	37.8	7.1
October	38.1	140.2
November	15.5	171.9
December	18.3	12.2
Total	520.7	1080.6

[a] Source: NCDC-NOAA (2003 and 2004).
[b] Data in mm.

APPENDIX E

COASTAL BERMUDAGRASS INJURY (NECROSIS)

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e. ha	--------------------------------------%------------------------------------			
Picloram + Diflufenzopyr	0.07 + 0.028	1.8 abc[a]	0.0 a	1.3 a	0.0 a
Picloram + Diflufenzopyr	0.14 + 0.028	1.8 abc	0.0 a	0.8 abc	0.0 a
Picloram + Diflufenzopyr	0.14 + 0.056	2.0 ab	0.0 a	0.8 abc	0.0 a
Picloram + Diflufenzopyr	0.28 + 0.056	1.0 cd	0.0 a	0.8 abc	0.0 a
Picloram + Diflufenzopyr	0.28 + 0.112	1.0 cd	0.0 a	0.8 abc	0.0 a
Picloram + Diflufenzopyr	0.56 + 0.112	1.5 bcd	0.0 a	0.5 bcd	0.0 a
Triclopyr + Diflufenzopyr	0.21 + 0.028	1.5 bcd	0.0 a	1.3 a	0.0 a
Triclopyr + Diflufenzopyr	0.21 + 0.056	1.0 cd	0.0 a	1.0 ab	0.0 a
Overdrive®	0.28	1.3 bcd	0.0 a	0.8 abc	0.0 a
Overdrive®	0.56	1.8 abc	0.0 a	0.5 bcd	0.0 a

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e. ha	---------------	-------%	--------	---------------
Picloram	0.07	1.0 cd [a]	0.0 a	0.8 abc	0.0 a
Picloram	0.14	1.0 cd	0.0 a	0.3 cd	0.0 a
Picloram	0.28	1.0 cd	0.0 a	0.3 cd	0.0 a
Picloram	0.56	1.0 cd	0.0 a	0.3 cd	0.0 a
Triclopyr	0.21	0.8 d	0.0 a	0.3 cd	0.0 a
Diflufenzopyr	0.028	1.3 bcd	0.0 a	0.0 d	0.0 a
Diflufenzopyr	0.056	2.5 a	0.0 a	0.0 d	0.0 a
Diflufenzopyr	0.112	1.3 bcd	0.0 a	0.0 d	0.0 a
Untreated	-	1.5 bcd	0.0 a	0.3 b	0.0 a

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

APPENDIX F

COASTAL BERMUDAGRASS INJURY (CHLOROSIS)

		2003		2004	
Herbicide	Rate	Harvest 1	Harvest 2	Harvest 1	Harvest 2
	kg a.e. ha	--------------------	--------------------	% --------------------	--------------------
Picloram + Diflufenzopyr	0.07 + 0.028	0.3 ab[a]	0.0 a	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.14 + 0.028	0.0 b	0.0 a	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.14 + 0.056	0.0 b	0.0 a	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.28 + 0.056	0.0 b	0.0 a	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.28 + 0.112	0.0 b	0.0 a	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.56 + 0.112	0.3 ab	0.0 a	0.0 a	0.0 a
Triclopyr + Diflufenzopyr	0.21 + 0.028	0.0 b	0.0 a	0.0 a	0.0 a
Triclopyr + Diflufenzopyr	0.21 + 0.056	0.0 b	0.0 a	0.0 a	0.0 a
Overdrive®	0.28	0.0 b	0.0 a	0.0 a	0.0 a
Overdrive®	0.56	0.0 b	0.0 a	0.0 a	0.0 a

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e. ha	---------------%	---------------	---------------	---------------
Picloram	0.07	0.5 a[a]	0.0 a	0.0 a	0.0 a
Picloram	0.14	0.0 b	0.0 a	0.0 a	0.0 a
Picloram	0.28	0.3 ab	0.0 a	0.0 a	0.0 a
Picloram	0.56	0.0 b	0.0 a	0.0 a	0.0 a
Triclopyr	0.21	0.0 b	0.0 a	0.0 a	0.0 a
Diflufenzopyr	0.028	0.0 b	0.0 a	0.0 a	0.0 a
Diflufenzopyr	0.056	0.0 b	0.0 a	0.0 a	0.0 a
Diflufenzopyr	0.112	0.0 b	0.0 a	0.0 a	0.0 a
Untreated	-	0.0 b	0.0 a	0.0 a	0.0 a

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

APPENDIX G

COASTAL BERMUDAGRASS CRUDE PROTEIN

Herbicide	Rate kg a.e. ha	2003 and 2004 Harvest 1	2003 and 2004 Harvest 2
		----------------%----------------	
Picloram + Diflufenzopyr	0.07 + 0.028	12.3 a[a]	12.4 a-e
Picloram + Diflufenzopyr	0.14 + 0.028	11.9 a-d	12.7 ab
Picloram + Diflufenzopyr	0.14 + 0.056	11.7 a-e	12.2 a-f
Picloram + Diflufenzopyr	0.28 + 0.056	12.2 ab	12.7 ab
Picloram + Diflufenzopyr	0.28 + 0.112	12.1 abc	12.5 a-e
Picloram + Diflufenzopyr	0.56 + 0.112	12.0 a-d	11.9 a-f
Triclopyr + Diflufenzopyr	0.21 + 0.028	10.9 def	11.5 c-f
Triclopyr + Diflufenzopyr	0.21 + 0.056	11.1 c-f	11.4 ef
Overdrive®	0.28	11.4 a-e	11.5 c-f
Overdrive®	0.56	11.1 c-f	11.2 f
Picloram	0.07	11.0 def	11.5 c-f
Picloram	0.14	11.8 a-e	12.0 a-f
Picloram	0.28	11.0 def	11.2 f
Picloram	0.56	10.8 e-f	11.5 def
Triclopyr	0.21	11.4 a-e	12.6 abc

Herbicide	Rate kg a.e. ha	2003 and 2004 Harvest 1	2
		----------------%----------------	
Diflufenzopyr	0.028	10.3 f[a]	12.1 a-f
Diflufenzopyr	0.056	11.3 a-e	12.6 a-d
Diflufenzopyr	0.112	11.8 a-e	13.0 a
Untreated	-	11.2 b-f	11.9 b-f

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

APPENDIX H

COASTAL BERMUDAGRASS ACID DETERGENT FIBER

		2003		2004	
Herbicide	Rate	Harvest 1	Harvest 2	Harvest 1	Harvest 2
	kg a.e. ha	----------------	----------------	%----------------	----------------
Picloram + Diflufenzopyr	0.07 + 0.028	32.3 ef[a]	35.0 ab	35.8 abc	36.3 a
Picloram + Diflufenzopyr	0.14 + 0.028	32.8 def	32.6 c	34.5 bcd	35.5 ab
Picloram + Diflufenzopyr	0.14 + 0.056	33.8 a-e	35.1 abc	34.6 bcd	35.8 a
Picloram + Diflufenzopyr	0.28 + 0.056	32.9 c-f	33.6 bc	34.1 cd	35.6 ab
Picloram + Diflufenzopyr	0.28 + 0.112	33.7 a-e	33.8 bc	34.7 bcd	36.0 a
Picloram + Diflufenzopyr	0.56 + 0.112	34.3 a-d	34.8 abc	34.5 bcd	35.3 ab
Triclopyr + Diflufenzopyr	0.21 + 0.028	32.9 c-f	34.3 abc	35.7 abc	36.1 a
Triclopyr + Diflufenzopyr	0.21 + 0.056	32.5 def	34.8 abc	35.3 a-d	36.1 a
Overdrive®	0.28	33.1 b-f	35.0 abc	33.2 d	36.8 a
Overdrive®	0.56	33.4 a-e	34.2 abc	35.0 a-d	36.3 a

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e. ha	------------------%	------------------%	------------------%	------------------%
Picloram	0.07	35.0 ab[a]	34.3 abc	35.0 a-d	35.2 ab
Picloram	0.14	31.3 f	34.8 abc	36.5 abc	35.9 a
Picloram	0.28	34.4 a-d	35.5 ab	36.1 abc	34.8 ab
Picloram	0.56	34.7 abc	36.7 a	36.9 ab	35.1 ab
Triclopyr	0.21	32.1 ef	33.5 bc	36.6 abc	34.6 ab
Diflufenzopyr	0.028	33.3 a-e	33.5 bc	37.3 a	35.3 ab
Diflufenzopyr	0.056	35.0 a	33.2 bc	35.5 a-d	36.1 a
Diflufenzopyr	0.112	33.9 a-e	33.0 bc	34.9 a-d	33.3 b
Untreated	-	34.0 a-e	34.8 abc	35.3 a-d	34.9 ab

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

APPENDIX I

COASTAL BERMUDAGRASS NEUTRAL DETERGENT FIBER

		2003		2004	
Herbicide	Rate	Harvest 1	Harvest 2	Harvest 1	Harvest 2
	kg a.e. ha	------------------%	------------------	------------------	------------------
Picloram + Diflufenzopyr	0.07 + 0.028	64.0 def[a]	67.9 ab	63.4 cd	63.9 abc
Picloram + Diflufenzopyr	0.14 + 0.028	64.5 c-f	66.5 b	65.3 a-d	64.6 ab
Picloram + Diflufenzopyr	0.14 + 0.056	64.5 c-f	67.8 ab	64.2 bcd	64.0 abc
Picloram + Diflufenzopyr	0.28 + 0.056	64.9 b-e	66.6 ab	64.1 bcd	64.7 ab
Picloram + Diflufenzopyr	0.28 + 0.112	65.4 a-d	67.3 ab	64.5 bcd	64.4 abc
Picloram + Diflufenzopyr	0.56 + 0.112	64.9 a-e	67.8 ab	64.3 bcd	63.8 abc
Triclopyr + Diflufenzopyr	0.21 + 0.028	64.9 a-e	66.8 ab	66.2 ab	64.8 ab
Triclopyr + Diflufenzopyr	0.21 + 0.056	64.2 c-f	66.5 b	65.2 a-d	64.6 ab
Overdrive®	0.28	64.4 c-f	67.4 ab	64.1 bcd	65.2 a
Overdrive®	0.56	65.3 a-e	66.1 ab	65.4 abc	65.7 a

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e. ha	----------------------------------	--------%--------	----------------------------------	
Picloram	0.07	66.5 a[a]	66.8 ab	64.7 bcd	64.0 abc
Picloram	0.14	62.9 f	66.6 ab	65.4 abc	64.0 abc
Picloram	0.28	65.7 abc	68.0 ab	64.6 bcd	63.1 abc
Picloram	0.56	66.1 ab	69.0 a	64.3 bcd	62.0 bc
Triclopyr	0.21	63.8 ef	66.5 b	66.1 ab	61.4 c
Diflufenzopyr	0.028	64.7 b-e	66.2 b	67.3 a	63.4 abc
Diflufenzopyr	0.056	65.3 a-e	66.2 b	63.0 d	64.1 abc
Diflufenzopyr	0.112	65.1 a-e	66.5 b	63.2 cd	61.4 c
Untreated	-	65.0 a-e	67.9 ab	64.1 bcd	63.5 abc

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

APPENDIX J

TIFTON 85 BERMUDAGRASS INJURY (NECROSIS)

Herbicide	Rate	2003		2004	
		Harvest 1	Harvest 2	Harvest 1	Harvest 2
	kg a.e. ha	%			
Picloram + Diflufenzopyr	0.07 + 0.028	7.5 g[a]	0.0 a	0.0 b	0.0 a
Picloram + Diflufenzopyr	0.14 + 0.028	18.8 e	0.0 a	0.0 b	0.0 a
Picloram + Diflufenzopyr	0.14 + 0.056	26.3 d	0.0 a	0.0 b	0.0 a
Picloram + Diflufenzopyr	0.28 + 0.056	36.3 c	0.0 a	0.0 b	0.0 a
Picloram + Diflufenzopyr	0.28 + 0.112	48.8 b	0.0 a	0.3 a	0.0 a
Picloram + Diflufenzopyr	0.56 + 0.112	62.5 a	0.0 a	0.0 b	0.0 a
Triclopyr + Diflufenzopyr	0.21 + 0.028	0.5 i	0.0 a	0.0 b	0.0 a
Triclopyr + Diflufenzopyr	0.21 + 0.056	1.3 i	0.0 a	0.0 b	0.0 a
Overdrive®	0.28	0.3 i	0.0 a	0.0 b	0.0 a
Overdrive®	0.56	0.0 i	0.0 a	0.3 a	0.0 a

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e. ha	----------------%	----------------	----------------	----------------
Picloram	0.07	1.0 i[a]	0.0 a	0.0 b	0.0 a
Picloram	0.14	2.0 hi	0.0 a	0.0 b	0.0 a
Picloram	0.28	6.0 g	0.0 a	0.0 b	0.0 a
Picloram	0.56	12.0 f	0.0 a	0.0 b	0.0 a
Triclopyr	0.21	0.5 i	0.0 a	0.0 b	0.0 a
Diflufenzopyr	0.028	1.5 i	0.0 a	0.0 b	0.0 a
Diflufenzopyr	0.056	2.8 hi	0.0 a	0.0 b	0.0 a
Diflufenzopyr	0.112	4.8 gh	0.0 a	0.0 b	0.0 a
Untreated	-	0.0 i	0.0 a	0.0 b	0.0 a

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

APPENDIX K

TIFTON 85 BERMUDAGRASS INJURY (CHLOROSIS)

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e. ha	--------------------	%	--------------------	
Picloram + Diflufenzopyr	0.07 + 0.028	0.0 a[a]	0.0 a	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.14 + 0.028	0.0 a	0.0 a	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.14 + 0.056	0.0 a	0.0 a	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.28 + 0.056	0.0 a	0.0 a	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.28 + 0.112	0.0 a	0.0 a	0.0 a	0.0 a
Picloram + Diflufenzopyr	0.56 + 0.112	0.0 a	0.0 a	0.0 a	0.0 a
Triclopyr + Diflufenzopyr	0.21 + 0.028	0.0 a	0.0 a	0.0 a	0.0 a
Triclopyr + Diflufenzopyr	0.21 + 0.056	0.0 a	0.0 a	0.0 a	0.0 a
Overdrive®	0.28	0.0 a	0.0 a	0.0 a	0.0 a
Overdrive®	0.56	0.0 a	0.0 a	0.0 a	0.0a

Herbicide	Rate	2003		2004	
		Harvest 1	Harvest 2	Harvest 1	Harvest 2
	kg a.e. ha	---%			
Picloram	0.07	0.0 a[a]	0.0 a	0.0 a	0.0 a
Picloram	0.14	0.0 a	0.0 a	0.0 a	0.0 a
Picloram	0.28	0.0 a	0.0 a	0.0 a	0.0 a
Picloram	0.56	0.0 a	0.0 a	0.0 a	0.0 a
Triclopyr	0.21	0.0 a	0.0 a	0.0 a	0.0 a
Diflufenzopyr	0.028	0.0 a	0.0 a	0.0 a	0.0 a
Diflufenzopyr	0.056	0.0 a	0.0 a	0.0 a	0.0 a
Diflufenzopyr	0.112	0.0 a	0.0 a	0.0 a	0.0 a
Untreated	-	0.0 a	0.0 a	0.0 a	0.0 a

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

APPENDIX L

TIFTON 85 BERMUDAGRASS CRUDE PROTEIN

Herbicide	Rate kg a.e. ha	2003 and 2004 Harvest 1	2003 and 2004 Harvest 2
		----------------%----------------	
Picloram + Diflufenzopyr	0.07 + 0.028	7.2 abc[a]	8.0 ab
Picloram + Diflufenzopyr	0.14 + 0.028	7.3 abc	8.1 ab
Picloram + Diflufenzopyr	0.14 + 0.056	7.7 abc	7.7 ab
Picloram + Diflufenzopyr	0.28 + 0.056	8.1 a	8.2 a
Picloram + Diflufenzopyr	0.28 + 0.112	7.6 abc	7.9 ab
Picloram + Diflufenzopyr	0.56 + 0.112	7.7 abc	7.8 ab
Triclopyr + Diflufenzopyr	0.21 + 0.028	6.9 bc	8.0 ab
Triclopyr + Diflufenzopyr	0.21 + 0.056	7.5 abc	7.7 ab
Overdrive®	0.28	7.5 abc	7.5 ab
Overdrive®	0.56	7.1 bc	7.7 ab
Picloram	0.07	6.9 c	7.9 ab
Picloram	0.14	7.4 abc	7.3 b
Picloram	0.28	7.2 bc	8.3 a
Picloram	0.56	7.1 bc	7.6 ab
Triclopyr	0.21	7.0 bc	7.7 ab

Herbicide	Rate kg a.e. ha	2003 and 2004	
		Harvest	
		1	2
		----------------%----------------	
Diflufenzopyr	0.028	7.8 abc[a]	7.6 ab
Diflufenzopyr	0.056	7.7 abc	7.9 ab
Diflufenzopyr	0.112	7.1 bc	8.0 ab
Untreated	-	7.8 ab	7.7 ab

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

APPENDIX M

TIFTON 85 BERMUDAGRASS ACID DETERGENT FIBER

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e. ha	------------------	%	------------------	
Picloram + Diflufenzopyr	0.07 + 0.028	40.0 ab[a]	38.3 ab	41.5 ab	36.4 ab
Picloram + Diflufenzopyr	0.14 + 0.028	41.0 a	39.0 a	40.8 b	36.1 b
Picloram + Diflufenzopyr	0.14 + 0.056	38.8 abc	38.1 ab	42.0 ab	37.0 ab
Picloram + Diflufenzopyr	0.28 + 0.056	36.6 c	38.5 ab	41.5 ab	36.4 ab
Picloram + Diflufenzopyr	0.28 + 0.112	38.8 abc	37.1 ab	41.5 ab	37.1 ab
Picloram + Diflufenzopyr	0.56 + 0.112	39.7 ab	38.6 ab	41.1 ab	35.9 b
Triclopyr + Diflufenzopyr	0.21 + 0.028	39.8 ab	38.3 ab	41.5 ab	37.7 ab
Triclopyr + Diflufenzopyr	0.21 + 0.056	39.3 abc	36.6 b	41.7 ab	37.7 ab
Overdrive®	0.28	38.8 abc	37.8 ab	41.2 ab	37.3 ab
Overdrive®	0.56	39.3 abc	38.5 ab	42.4 a	37.9 ab

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e. ha	------------------	------------------%	------------------	------------------
Picloram	0.07	40.3 ab[a]	38.5 ab	40.6 b	36.2 b
Picloram	0.14	38.5 abc	39.3 a	41.8 ab	38.7 a
Picloram	0.28	39.5 abc	39.2 a	42.7 a	36.3 ab
Picloram	0.56	38.5 abc	39.3 a	42.2 ab	36.6 ab
Triclopyr	0.21	38.4 abc	37.8 ab	42.1 ab	37.4 ab
Diflufenzopyr	0.028	37.7 bc	38.0 ab	41.2 ab	37.0 ab
Diflufenzopyr	0.056	39.1 abc	39.2 a	40.5 b	36.9 ab
Diflufenzopyr	0.112	40.6 ab	37.9 ab	41.9 ab	35.5 b
Untreated	-	37.9 bc	38.4 ab	40.7 b	37.2 ab

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

APPENDIX N

TIFTON 85 BERMUDAGRASS NEUTRAL DETERGENT FIBER

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e. ha	%			
Picloram + Diflufenzopyr	0.07 + 0.028	68.5 a-d[a]	67.0 ab	71.7 a-e	66.2 abc
Picloram + Diflufenzopyr	0.14 + 0.028	69.1 ab	67.8 ab	70.2 de	65.8 abc
Picloram + Diflufenzopyr	0.14 + 0.056	65.7 d-g	67.0 ab	71.1 a-e	66.8 abc
Picloram + Diflufenzopyr	0.28 + 0.056	63.3 g	67.3 ab	71.2 a-e	65.9 abc
Picloram + Diflufenzopyr	0.28 + 0.112	65.3 efg	66.3 ab	70.4 cde	67.1 abc
Picloram + Diflufenzopyr	0.56 + 0.112	64.7 fg	67.4 ab	70.5 b-e	66.3 abc
Triclopyr + Diflufenzopyr	0.21 + 0.028	68.7 abc	67.0 ab	71.6 a-e	65.7 abc
Triclopyr + Diflufenzopyr	0.21 + 0.056	67.8 a-e	65.4 b	72.6 a	67.8 ab
Overdrive®	0.28	67.6 a-e	67.0 ab	72.2 a-d	67.1 abc
Overdrive®	0.56	68.1 a-e	67.6 ab	71.5 a-e	67.2 abc

Herbicide	Rate	2003 Harvest 1	2003 Harvest 2	2004 Harvest 1	2004 Harvest 2
	kg a.e. ha	-------------------	%	-------------------	
Picloram	0.07	69.1 ab[a]	68.0 a	70.9 a-e	65.4 c
Picloram	0.14	67.1 b-f	68.3 a	71.7 a-e	67.7 abc
Picloram	0.28	68.2 a-d	67.3 a	72.4 abc	66.1 abc
Picloram	0.56	66.1 c-g	67.6 ab	72.5 ab	66.0 abc
Triclopyr	0.21	67.3 a-f	66.4 ab	72.3 a-d	67.9 a
Diflufenzopyr	0.028	66.4 b-f	67.2 ab	72.1 a-d	66.5 abc
Diflufenzopyr	0.056	67.9 a-e	66.7 ab	70.9 a-e	66.0 abc
Diflufenzopyr	0.112	70.0 a	66.9 ab	69.8 e	65.5 bc
Untreated	-	66.7 b-f	66.4 ab	70.7 a-e	67.0 abc

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

APPENDIX O

SILVERLEAF NIGHTSHADE AND WESTERN RAGWEED STEM REGROWTH COUNTS

Herbicide	Rate	2003 Western Ragweed 10 MAT	2004 Western Ragweed 11 MAT	2004 Silverleaf Nightshade 13 MAT
	kg a.e./ha	------------------------Plants/$2m^2$	------------------------	
Picloram + Diflufenzopyr	0.07 + 0.028	20.3 ab	10.3 bcd	27.3 b-f
Picloram + Diflufenzopyr	0.14 + 0.028	6.3 b	9.0 bcd	15.7 f
Picloram + Diflufenzopyr	0.14 + 0.056	35.3 ab	5.3 bcd	33.0 a-f
Picloram + Diflufenzopyr	0.28 + 0.056	46.3 ab	2.7 d	27.3 b-f
Picloram + Diflufenzopyr	0.28 + 0.112	35.7 ab	6.0 bcd	23.0 c-f
Picloram + Diflufenzopyr	0.56 + 0.112	29.7 ab	4.3 cd	21.0 ef
Triclopyr + Diflufenzopyr	0.21 + 0.028	53.3 a	5.0 cd	32.7 a-f
Triclopyr + Diflufenzopyr	0.21 + 0.056	52.0 a	6.0 bcd	38.7 a-d
Overdrive®	0.28	31.3 ab	21.3 ab	36.0 a-e
Overdrive®	0.56	46.7 ab	4.3 cd	33.3 a-e

Herbicide	Rate	2003 Western Ragweed 10 MAT	2004 Western Ragweed 11 MAT	2004 Silverleaf Nightshade 13 MAT
	kg a.e./ha	------------------------Plants/2m^2------------------------		
Picloram	0.07	28.3 ab	13.7 bcd	42.7 ab
Picloram	0.14	57.7 a	6.0 bcd	33.7 a-e
Picloram	0.28	34.0 ab	31.7 a	36.0 a-e
Picloram	0.56	20.3 ab	19.3 abc	22.0 def
Triclopyr	0.21	45.3 ab	5.7 bcd	21.7 def
Diflufenzopyr	0.028	37.0 ab	9.3 bcd	20.7 ef
Diflufenzopyr	0.056	54.3 a	10.3 bcd	39.7 abc
Diflufenzopyr	0.112	43.7 ab	19.0 abc	48.3 a
Untreated	-	58.0 a	7.3 bcd	35.3 a-e

[a] Means within a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

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