Use of Selected Herbicides and Application Methods for Tolerance to Tifton 85 Bermudagrass [*Cynodon dactylon* (L.) Pers.]

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Abstract

Aims: To evaluate forage tolerance of Tifton 85 bermudagrass to selected pasture herbicides using two application methods: broadcast (BRD) and individual plant treatments (IPT).

Study design: A randomized complete block design was employed with four replications.

Place and duration of study: Trials were conducted during the 2006 and 2007 growing seasons near Thrall, Texas, (30.35^{o} N, 97.17^{o} W).

Methodology: Two spray application methods (BRD and IPT) were compared when using selected herbicides for bermudagrass tolerance. Herbicides evaluated by BRD included picloram plus fluroxypyr, picloram plus fluroxypyr plus metsulfuron-methyl, triclopyr, triclopyr plus fluroxypyr, triclopyr plus metsulfuron-methyl, triclopyr plus fluroxypyr plus metsulfuron-methyl, and metsulfuron-methyl plus dicamba plus 2,4-D. Herbicides evaluated by IPT included triclopyr, triclopyr plus fluroxypyr, and picloram plus fluroxypyr. Bermudagrass injury, yield, and crude protein content were evaluated for application method and herbicide.

Results: Rainfall after herbicide application in 2006 was 67% below normal while in 2007 rainfall was 350% above normal. No bermudagrass necrosis or growth reduction were noted in 2006. Triclopyr plus fluroxypyr applied IPT was the only treatment to decrease Tifton 85 dry matter yield at the first harvest, with no effect observed at the second. In 2007, necrosis was greatest with triclopyr plus fluroxypyr applied BRD while triclopyr plus fluroxypyr and triclopyr plus fluroxypyr plus metsulfuron-methyl applied BRD and triclopyr applied IPT caused the greatest growth reduction. Triclopyr and triclopyr plus fluroxypyr applied BRD or IPT and triclopyr plus fluroxypyr plus metsulfuron-methyl applied BRD decreased dry matter yield at the first harvest while only triclopyr alone applied IPT reduced yield at the second.

Conclusions: The recurring bermudagrass stunting and yield reduction with triclopyr is consistent with previous forage tolerance research. Metsulfuron methyl plus dicamba plus 2,4-D was the only treatment that exhibited little or no injury, growth reduction, or yield reduction at any time. Producers need to be aware of potential injury issues with triclopyr prior to its use.

Keywords: Bermudagrass tolerance, broadcast, herbicides, individual plant treatment, bermudagrass yield.

1. Introduction

Bermudagrass [*Cynodon dactylon* (L.) Pers.] is the most important and widely used perennial forage grass in the southern United States [1,2] and occurs on approximately 12 million ha used for livestock grazing and hay production in the US [3]. Tifton 85 bermudagrass was released in 1992 by the University of Georgia and USDA-ARS as a higher producing and more digestible hybrid than Coastal bermudagrass [4]. Tifton 85 is desired by forage producers due to its large rhizomes and rapidly spreading stolons [5,6].

Previous studies on bermudagrass tolerance to herbicides have yielded variable results. Bovey et al. [7] reported that 2,4-D at rates of 1.1 to 2.2 kg ai ha^{-1}did not reduce yield of Coastal bermudagrass in any year of the study while picloram applied at 0.5 kg ai ha^{-1} reduced yield in the first year. On Midland bermudagrass (Coastal x common), Koger et al. [8] found that picloram at 0.5 kg ai ha^{-1} did not reduce Midland bermudagrass yield while triclopyr at 1.1 kg ai ha^{-1} reduced both yield and density. Yield reductions from imazapic plus 2,4-D on Coastal bermudagrass has been reported at the first harvest [9,10,11,12]. Warren et al. [11] reported that imazapic plus 2,4-D treatments resulted in Coastal bermudagrass yields that were approximately 50% of the control at the first harvest. They also reported that the total production of Coastal bermudagrass when using imazapic plus 2,4-D never fully recovered by the end of the growing season.

Registered in 2004 for use in the US, fluroxypyr has become available to producers for weed control in bermudagrass [13]. Butler and Muir [14] evaluated Coastal bermudagrass tolerance to picloram plus fluroxypyr at 0.2 kg ai ha^{-1} plus 0.2 kg ai ha^{-1} and triclopyr plus fluroxypyr at 0.6 kg ai ha^{-1}plus 0.2 kg ai ha^{-1} for two years in north-central Texas. In 2001, with below average rainfall, picloram plus fluroxypyr decreased bermudagrass dry matter yield by 50% at the first harvest, but did not reduce yield at the second or third harvest. In 2002, a year with near normal rainfall, picloram plus fluroxypyr reduced dry matter yield at the first harvest by 49%, but not at harvests two, three, and four. In 2001 and 2002, total (annual) dry matter yield with picloram plus fluroxypyr was reduced 17% and 22%, respectively. Triclopyr plus fluroxypyr at the 0.6 kg ai ha^{-1} plus 0.2 kg ai ha^{-1} rate reduced bermudagrass dry matter yield 38% at the first harvest in 2001 and 41% at the first harvest in 2002. In neither year was a reduction in biomass observed at harvests two, three, or four with the triclopyr plus fluroxypyr treatment. Overall, in 2001 and

2002, total dry matter yield with triclopyr plus fluroxypyr was reduced by 17% and 19%, respectively. In this same study, triclopyr applied alone at 1.7 kg ai ha^{-1} resulted in a 37% decrease in dry matter production at the first harvest in 2001, while a 41% reduction in dry matter yield was observed at the first harvest in 2002. No reduction in dry matter yield was observed in subsequent harvests in either year. No cumulative loss in total dry matter production occurred in 2001 or 2002 when triclopyr was applied at 1.7 kg ai ha^{-1}. Treatments of 2,4-D amine plus dicamba at 1.2 kg ai ha^{-1} plus 0.4 kg ai ha^{-1}, metsulfuron plus 2,4-D amine plus dicamba at 0.02 kg ai ha^{-1} plus 0.1 kg ai ha^{-1} plus 0.3 kg ai ha^{-1}, and 2,4-D ester at 2.3 kg ai ha^{-1} did not negatively affect bermudagrass dry matter yield. Also, metsulfuron at the 0.02 kg ai ha^{-1} rate did not decrease bermudagrass dry matter yield when applied as a tank mix with 2,4-D amine plus dicamba. Eichhorn and Wells [15] demonstrated that metsulfuron applied alone at either 0.01 kg ai ha^{-1} or 0.02 kg ai ha^{-1} to Coastal bermudagrass did not exhibit any visual phytotoxicity and did not affect forage yield or quality. These tolerance results for Coastal bermudagrass provide insight into possible tolerance issues associated with applying these herbicides and tank mixes to Tifton 85 bermudagrass.

It is important that herbicides used in pastures and rangeland provide adequate weed control and not adversely affect forage quality or yield [14]. While broadcast treatments are commonly evaluated in pasture, the use of high spray carrier volume individual plant treatments (IPT) are seldom reported on but are deemed necessary because brush infestations are becoming more of an issue in Tifton pastures. While there has been some research on herbicide tolerance to Tifton 85 bermudagrass using broadcast application methods [5,6,16,17], there are little data on how higher spray carrier volume IPT application methods affect tolerance. Therefore, the purpose of this study was to evaluate Tifton 85 bermudagrass tolerance to selected herbicide combinations

using both broadcast and IPT application methods and to assess phytotoxic injury (chlorosis and necrosis), growth reduction, bermudagrass yield response, and possible forage quality differences.

2. Materials and methods

2.1 Study site

Forage tolerance trials were conducted during the 2006 and 2007 growing seasons near Thrall, Texas, (30.35^{o} N, 97.17^{o} W) to determine Tifton 85 bermudagrass sensitivity to several herbicides and combinations. The research studies were conducted at the same location for two consecutive years at separate sites in the same field under weed-free conditions. The soil type at this location was a Burleson clay (Fine, smectitic, thermic Udic Haplusterts) with 2.0% organic matter and pH 7.0. A randomized complete block design was employed with four replications and an individual plot size of three by six meters.

2.2 Herbicides and doses

Broadcast treatments consisted of picloram plus fluroxypyr (Surmount, Dow AgroSciences, Indianapolis, IN 46268) at 0.5 kg ai ha^{-1} plus 0.5 kg ai ha^{-1}, picloram plus fluroxypyr plus metsulfuron-methyl (Cimarron, DuPont Crop Protection, Wilmington, DE 19898) at 0.5 kg ai ha^{-1} plus 0.5 kg ai ha^{-1} plus 0.01 kg ai ha^{-1}, triclopyr ester plus fluroxypyr (PastureGard, Dow AgroSciences, Indianapolis, IN 46268) at 0.9 kg ai ha^{-1} plus 0.3 kg ai ha^{-1}, triclopyr plus fluroxypyr plus metsulfuron-methyl at 0.9 kg ai ha^{-1} plus 0.3 kg ai ha^{-1} plus 0.01 kg ai ha^{-1}, triclopyr (Remedy, Dow AgroSciences, Indianapolis, IN 46268) at 0.8 kg ai ha^{-1}, triclopyr plus metsulfuron-methyl at 0.8 kg ai ha^{-1} plus 0.01 kg ai ha^{-1}, and metsulfuron-methyl plus dicamba plus 2,4-D (Cimarron Max, DuPont Crop Protection, Wilmington, DE 19898) at 0.02 kg ai ha^{-1} plus 0.3 kg ai ha^{-1} plus 0.8 kg ai ha^{-1}. IPT treatments included triclopyr alone at 0.3% ai v/v,

picloram plus fluroxypyr at 0.13% ai v/v plus 0.1% ai v/v, and triclopyr plus fluroxypyr at 0.25% ai v/v plus 0.09% ai v/v. An untreated control was also included in each study. All herbicide treatments used water as the carrier with 0.5% v/v non-ionic surfactant (Activator 90®, Loveland Industries, Inc., P.O. Box 1289, Greeley, CO 80632).

2.3 Herbicide applications

Applications were made on July 10, 2006, and June 8, 2007 to 15 cm tall actively growing bermudagrass, either broadcast (BRD) or as an individual plant treatment (IPT). BRD treatments were applied in water using a CO_2-pressurized backpack sprayer with TeeJet® 11003 DG (Spraying Systems Company, P.O. Box 7900, North Avenue, Wheaton, IL 60188) nozzles calibrated to deliver 190 L/ha at 228 kPa. IPT treatments were applied in water using a SP Systems Farm and Home 20 pump-up sprayer (SP Systems International, 1618 Stanford St., Ste. C, Santa Monica, CA 90404) with a single nozzle hand wand with a TeeJet® 5500-PPB-X6 nozzle at 240 kPa in a spray-to-wet method [18,19]. Since there was a solid stand of weed-free bermudagrass, application as an IPT resulted in the entire plot area being sprayed with each herbicide treatment and led to an application volume of 0.7 L to each 3 m x 6 m plot, equivalent to 374 L/ha on a per area basis. This volume remained consistent for each IPT application.

Due to the dry conditions of 2006 (Table 1), the study was not initiated until mid-summer and the first harvest did not take place until mid-August. At the time of herbicide application in 2006, the air temperature was 36° C and the relative humidity was 41% while in 2007 the air temperature was 32° C and the relative humidity was 58% (Table 2).

2.4 Data collection

Visual forage injury evaluations including percent chlorosis, necrosis, and growth reduction were made at 1, 3, and 5 weeks after application (WAA). Chlorosis, necrosis, and growth reduction

ratings were based on a scale of 0 to 100%, where 0 indicates no chlorosis, necrosis or growth reduction and 100 represents total plant yellowing, desiccation, or total cessation of growth compared to untreated plots. Two harvests were collected in each year from a 0.9 by 6 m area of each plot with a Carter® flail harvester (Carter Manufacturing Company, Inc.; Brookston, IN 47923) throughout the growing seasons to determine herbicide effect on forage dry matter yield and quality. Harvests were made on August 16, 2006 (38 days after treatment [DAT]), October 13, 2006 (96 DAT), July 10, 2007 (33 DAT), and August 24, 2007 (78 DAT). 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 hours. 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) (FOSS NIRSystems, Inc., Laurel, MD 20723) analysis to determine percent crude protein (CP) content of the bermudagrass.

2.5 Statistical analysis

Data for percent chlorosis, necrosis, and growth reduction of bermudagrass were transformed to the arcsine square root prior to analysis; however, nontransformed means are presented because arcsine transformation did not affect analysis of the data. All data were subjected to ANOVA and means were separated using Duncan's new multiple range test at the 0.05 significance level. The untreated control was included in the yield and crude protein analysis and only as a visual comparison for bermudagrass chlorosis, necrosis, and growth reduction but was not included in the data analysis. All data, with the exception of chlorosis damage, are presented by years due to a treatment by year interaction. Only chlorosis damage was combined over years due to a lack of treatment by year interaction.

3. Results

3.1 Rainfall

Rainfall for 2006 was below normal for the early part of the growing season from March through August but above normal for September and October. In 2007, rainfall was well above normal for March, May, and July and slightly above normal for June [20] (Table 1).

3.2 Chlorosis

All treatments exhibited chlorosis when compared to the untreated check 1 wk after herbicide application (Table 3). Picloram plus fluroxypyr applied either BRD or as IPT resulted in the greatest chlorosis (10%) while the combination of metsulfuron-methyl plus dicamba plus 2,4-D exhibited the least amount of chlorosis (3%). Triclopyr alone applied either BRD or IPT also resulted in less chlorosis than combinations of triclopyr plus fluroxypyr. Chlorosis persisted for 2 to 4 weeks after herbicide application; however, little or no chlorosis was observed at later rating dates from any of the treatments (data not shown).

3.3 Necrosis

In 2006 when rated 5 WAA, no necrosis was found with any herbicide treatments while in 2007 when rated 3 WAA, all herbicide treatments with the exception of metsulfuron-methyl plus dicamba plus 2,4-D exhibited at least 6% necrosis (Table 3). Triclopyr plus fluroxypyr applied BRD showed the greatest amount of necrosis (14%) while picloram plus fluroxypyr applied as IPT resulted in the least amount (6%). The lack of necrosis seen in 2006 may be due to the later rating date in 2006 compared with 2007 as well as a lack of rainfall during the month of application as well as the month following application (Table 1). Postemergence herbicide efficacy may be affected by environmental factors including air temperature, relative humidity, and dew or precipitation [21,22,23]. These environmental conditions may influence processes

such as herbicide absorption, translocation, or plant metabolism, which influence herbicide efficacy [24]. Conditions at time of herbicide application (Table 2) were much more favorable for translocation of the herbicide within the plant in 2007 than 2006.

Triclopyr has been reported to significantly injure both common and 'hybrid' bermudagrass [*Cynodon dacylon* (L.) Pers. X *C. transvaalensis* Burtt-Davy] when applied at twice the labeled rate [25]. Multiple applications of triclopyr at 0.5 kg ha^{-1} or triclopyr plus clopyralid at 0.5 kg ha^{-1} plus 0.6 kg ha^{-1} has been reported to injure bermudagrass up to 30% [26].

3.4 Growth reduction

In 2006 at 5 WAA, growth reduction occurred with triclopyr alone and triclopyr plus metsulfuron-methyl applied BRD and triclopyr plus fluroxypyr applied IPT (Table 2). Growth reduction was not assessed earlier than 5 WAA due to excessively dry conditions after application (Table 1). However, growth reduction was observed in 2007 at 1 and 3 WAA. At 1 WAA, all treatments with the exception of the combination of metsulfuron-methyl plus dicamba plus 2,4-D showed at least 5% visual growth reduction. The greatest growth reduction (10%) was seen with triclopyr plus fluroxypyr applied as an IPT (Table 3). By 3 WAA, all treatments with the exception of the metsulfuron-methyl plus dicamba plus 2,4-D combination had at least 10% growth reduction . All triclopyr containing treatments with the exception of triclopyr plus metsulfuron-methyl resulted in a greater growth reduction (19 to 24%) than treatments which contained picloram ($\leq$ 11%). In contrast, Butler and Evers [27] reported no reduction in bermudagrass growth when triclopyr plus fluroxypyr, picloram plus fluroxypyr, or triclopyr plus clopyralid was applied to newly sprigged "Coastal" and "Tifton 85" bermudagrass and they concluded that these herbicides could be safely used on newly established bermudagrass sprigs.

3.5 Bermudagrass yield

In 2006, at the first harvest, only triclopyr plus fluroxypyr applied as IPT resulted in lower dry matter yield than the untreated check while at the second harvest there were no differences in yield from the untreated check (Table 4). In 2007 at the first harvest, triclopyr alone and triclopyr plus fluroxypyr applied either BRD or as an IPT and triclopyr plus fluroxypyr plus metsulfuron-methyl applied BRD provided a lower dry matter yield when compared to the untreated control (Table 4). At the second harvest only triclopyr alone applied as an IPT reduced forage yield when compared with the untreated check.

3.6 Crude protein content

Crude protein is one measure of the nutritive value of bermudagrass forage. In 2006 at the first harvest, the untreated check produced higher crude protein content than all treatments with the exception of picloram plus fluroxypyr, picloram plus fluroxypyr plus metsulfuron-methyl, and triclopyr plus fluroxypyr applied BRD or picloram plus fluroxypyr applied IPT. At the second harvest, there were no differences in crude protein content between herbicide treatments and the untreated check (Table 5). In 2007, no differences were found in crude protein content between the untreated check and any of the herbicide treatments at the first harvest. At the second harvest, no differences in crude protein content were found between the untreated check and any herbicide treatment; however, triclopyr plus fluroxypyr applied IPT produced the highest crude protein content and this was greater than the BRD treatments of picloram plus fluroxypyr, triclopyr plus fluroxypyr plus metsulfuron-methyl, triclopyr alone, and metsulfuron-methyl plus dicamba plus 2,4-D.

4. Discussion

The difference in bermudagrass response between years can be best explained by the differences in environmental conditions at herbicide application (Table 2) and for 1 month after (Table 1).

Conditions in 2007 were much more favorable for herbicide movement in the plant than in 2006 when conditions were extremely dry. Plant stress may reduce systemic herbicide activity and account for relatively poor weed control or lack of injury. Buhler and Burnside [28] noted that glyphosate was less effective on drought-stressed annual grass species than actively growing plants while Stewart et al. [23] reported reduced common ragweed (*Ambrosia artemisiifolia* L.) control with dicamba in a year where 66% less precipitation was received compared to the 30-yr average. Morton and Harvey [29] found similar results with primisulfuron applied POST on quackgrass [*Elytrigia repens* (L.) Nevski] in dry conditions and attributed the result to reduced translocation.

The relative humidity was greater in 2007 (Table 2) and therefore may have resulted in better movement of the herbicide into the plant. Generally, high relative humidity increased plant susceptibility to postemergence herbicides [23]. For example, glyphosate activity or absorption increased with increasing relative humidity for quackgrass [28], bermudagrass [30], liverseedgrass (*Urochloa panicoides* Beauv.) [31], junglerice [*Echinochloa colona* (L.) Link] [32], and johnsongrass (*Sorghum halepense* L.) [33].

Dew was also present in 2007 but not 2006 (Table 2). Dew, defined as the presence of free water on plant foliage [34] could affect foliar uptake and therefore efficacy of foliar-applied herbicides, mainly those of high water solubility. The presence of dew at application is believed to increase or decrease foliar herbicide efficacy [35]. Herbicide runoff and herbicide dilution could explain the negative effect of dew. By contrast, dew can increase the total area of herbicide interception and reduce the impact of large drops on foliage surfaces, avoiding their loss from the leaves [36]. At the same time, the presence of dew results in hydration of the cuticle and may play an important role favoring foliar uptake [34].

4. Conclusion

The recurring bermudagrass stunting and yield reduction with triclopyr is consistent with previous forage tolerance research by Koger et al. [8] who found that triclopyr at 1.1 kg ai ha^{-1} reduced both forage density and yield. Interestingly, metsulfuron methyl plus dicamba plus 2,4-D at 0.02 kg ai ha^{-1} plus 0.3 kg ai ha^{-1} plus 0.8 kg ai ha^{-1} was the only treatment that exhibited little chlorosis and no necrosis, growth reduction, yield reduction at any time. Little or no injury from the treatment containing metsulfuron methyl plus dicamba plus 2,4-D replicates the results found by Butler and Muir [14] when evaluating Coastal bermudagrass tolerance to these herbicides. Producers need to be aware of potential injury issues with triclopyr prior to its use as well as have a knowledge of those herbicides, such as metsulfuron, dicamba, and 2,4-D, which may provide satisfactory weed control while having no documented adverse effect on the desirable bermudagrass forage.

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Table 1. Precipitation for the 2006 and 2007 growing seasons near Thrall, TX.[a]

Month	2006	2007	30-yr average
	mm		
March	61	161	64
April	47	39	58
May	52	251	68
June	88	116	111
July	15	216	62
August	14	27	41
September	68	20	63
October	147	40	100
Total	492	870	567

[a] Office of the state climatologist, 2013.

Table 2. Weather conditions at time of herbicide application in 2006 and 2007.

Variable	2006	2007
Air temp (C^o)	36	32
Relative humidity (%)	41	58
Dew presence	No	Yes
Soil moisture	Fair	Excellent
Soil (10 cm) temp (C^o)	24	23

Table 3. Response of Tifton 85 bermudagrass to selected herbicides applied broadcast or as individual plant treatments.[a]

Herbicide[b]	Rate	Appl method		Necrosis[d]		Growth reduction		
				5 WK	3 WK	5 WK	1 WK	3 WK
			Chlorosis[c]	2006	2007	2006	2007	
	Kg ae or ai ha^{-1}	%						
Picloram + fluroxypyr	0.5 + 0.5	BRD	10	0	9	0	5	11
Picloram + fluroxypyr + metsulfuron-methyl	0.5 + 0.5 + 0.01	BRD	8	0	8	0	5	10
Triclopyr + fluroxypyr	0.9 + 0.3	BRD	6	0	14	0	5	20
Triclopyr + fluroxypyr + metsulfuron-methyl	0.9 + 0.3 + 0.01	BRD	6	0	10	0	5	20
Triclopyr	0.8	BRD	4	0	8	4	5	19
Triclopyr + metsulfuron-methyl	0.8 + 0.01	BRD	5	0	8	3	5	14
Metsulfuron-methyl + dicamba + 2,4-D	0.02 + 0.3 + 0.8	BRD	3	0	0	0	0	0
Triclopyr	0.3 % ai v/v	IPT	5	0	9	0	6	24
Picloram + fluroxypyr	0.13 % ai v/v + 0.1 %ai v/v	IPT	10	0	6	0	5	11
Triclopyr + fluroxypyr	0.25 % ai v/v + 0.09 % ai v/v	IPT	8	0	11	5	10	19
Untreated	-	-	0	0	0	0	0	0
LSD (0.05)			1	0	3	2	1	4

[a] Abbreviations: BRD, broadcast; IPT, individual plant treatment; WK, weeks after application.
[b] Broadcast treatments applied at 187 L ha^{-1}; IPT applied at 0.7 L to each 3 by 6 m plot.
[c] Chlorosis was yellowing of treated plant tissues. Ratings taken 1 WKin both years.
[d] Necrosis was desiccation/death of treated plant tissues.

Table 4. Tifton 85 bermudagrass yields as influenced by selected herbicides.[a]

Herbicide	Rate	Appl method	Yield			
			2006		2007	
			Harvest 1[b]	Harvest 2	Harvest 1	Harvest 2
	Kg ae or ai ha^{-1}		Kg ha^{-1}			
Picloram + fluroxypyr	0.5 + 0.5	BRD	3290	2780	6120	4470
Picloram + fluroxypyr + metsulfuron-methyl	0.5 + 0.5 + 0.01	BRD	3230	2810	6460	3920
Triclopyr + fluroxypyr	0.9 + 0.3	BRD	3280	2450	5450	4000
Triclopyr + fluroxypyr + metsulfuron-methyl	0.9 + 0.3 + 0.01	BRD	2650	2680	5470	4110
Triclopyr	0.8	BRD	2670	2600	5690	4060
Triclopyr + metsulfuron-methyl	0.8 + 0.01	BRD	3040	2440	5780	4280
Metsulfuron-methyl + dicamba + 2,4-D	0.02 + 0.3 + 0.8 + 0.805	BRD	2555	2750	7260	4080
Triclopyr	0.3 % ai v/v	IPT	2745	2580	5120	3570
Picloram + fluroxypyr	0.13 % ai v/v +	IPT	3242	2400	6290	4050
Triclopyr + fluroxypyr	0.25 % ai v/v +	IPT	2222	2480	5600	4020
Untreated	-	-	3280	2460	6640	4420
LSD (0.05)			820	NS	920	650

[a] Abbreviations: BRD, broadcast; IPT, individual plant treatment.
[b] Harvest dates: 8/16/2006, 38 days after treatment (DAT); 10/13/2006, 96 DAT; 7/10/2007, 33 DAT; 8/24/2007, 78 DAT.

Table 5. Tifton 85 bermudagrass crude protein content as influenced by selected herbicides.[a]

Herbicide[b]	Rate	Appl method	Crude protein[c]			
			2006		2007	
			Harvest 1	Harvest 2	Harvest 1	Harvest 2
	Kg ae or ai ha^{-1}		%			
Picloram + fluroxypyr	0.5 + 0.5	BRD	8.0	17.3	9.3	11.1
Picloram + fluroxypyr + metsulfuron-methyl	0.5 + 0.5 + 0.01	BRD	7.7	17.0	9.4	11.8
Triclopyr + fluroxypyr	0.9 + 0.3	BRD	7.8	17.2	9.5	11.5
Triclopyr + fluroxypyr + metsulfuron-methyl	0.9 + 0.3 + 0.01	BRD	7.0	17.0	9.2	10.7
Triclopyr	0.8	BRD	7.3	17.1	9.5	10.6
Triclopyr + metsulfuron-methyl	0.8 + 0.01	BRD	7.4	17.9	9.0	11.9
Metsulfuron-methyl + dicamba + 2,4-D	0.02 + 0.3 + 0.8	BRD	7.1	17.6	8.6	10.6
Triclopyr	0.3 % ai v/v	IPT	7.2	17.2	10.2	11.9
Picloram + fluroxypyr	0.13 % ai v/v + 0.1 %ai v/v	IPT	7.7	18.1	9.0	11.4
Triclopyr + fluroxypyr	0.25 % ai v/v + 0.09 % ai v/v	IPT	7.3	17.8	9.4	13.6
Untreated	-		8.3	17.3	9.6	11.6
LSD	-		0.8	NS	NS	2.3

[a] Abbreviations: BRD, broadcast; IPT, individual plant treatment.
[b] Broadcast treatments applied at 187 L ha^{-1}; IPT applied at 0.7 L to each 3 by 6 m plot.
[c] Percent crude protein determined by near infrared reflectance spectroscopy (NIRS).