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Original Research Article

Influence of Spray Tip and Spray Volume With Imazapic and Imazethapyr on Selected Weed Species

Abstract

Aims: To evaluate control of weeds commonly found in peanut fields when using imazapic or imazethapyr applied postemergence (POST) with different spray tips and at different spray volumes.

Study design: Experimental design was a randomized complete block with three replications and a seven (spray volume) or five (spray tip) by two (imazapic or imazethapyr) factorial arrangement of treatments.

Place and duration of study: Field studies were conducted during the 2006 and 2007 growing seasons in the south Texas and in the Texas High Plains peanut growing regions.

Methodology: Spray volumes of 47 to 187 L/ha, when using five different spray nozzle tips, were compared for control of the annual grasses *Urochloa texana* (Buckl.) R. Webster, and *Digitaria ciliaris* (Retz.) Koel. and the broadleaf weeds *Amaranthus palmeri* L., *Cucumis melo* L. var. Dudaim Naud., *Ipomoea lacunose* L., *Sida spinosa* L., *Solanum elaeagnifolium Cav.*, *Tribulus terrestris* L., and *Proboscidea louisianica* (Mill.) Thellung.

Results: *U. texana* control was not affected by spray volume but *D. ciliaris* control was affected. With *D. ciliaris*, as spray volume increased, herbicide efficacy decreased. The decrease in weed efficacy may be due to increased relative humidity related to above normal rainfall. Spray volume did affect *A. palmeri* efficacy. In both years at the High

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Plains location, a spray volume of 47 L/ha provided better control than 187 L/ha. *C. melo*, *I. lacunose*, *T. terrestris*, and *S. spinosa* control with both herbicides decreased as spray volume increased. Annual grass control was not affected by spray tip application while *A. palmeri* efficacy was reduced at one location with 110015XR nozzle tips. *C. melo*, *I. lacunose*, and *S. spinosa* control was not affected by spray tip; however, 110015TT and 110015FF provided the best control of *S. elaeagnifolium* and *P. louisianica*, respectively.

Conclusions: Depending on weed species the amount of carrier volume and spray tip can affect weed efficacy.

Keywords: Carrier volume, coverage, annual grasses, broadleaf weeds.

1. INTRODUCTION

The use of low spray volumes is preferred by growers and pesticide applicators because of time savings in filling sprayer tanks and traveling to and from fields [1]; however, growers have expressed concern that reduced efficacy may result with the use of lower spray volumes. Herbicide concentration increases as spray volume decreases, thereby enhancing efficacy of systemic herbicides in low spray volumes [2,3]. Also, Sandberg et al. [4] reported that spray runoff from plants may occur at spray volumes above 187 L/ha, leading to reduced herbicide efficacy.

Herbicide concentration in the spray droplet is important for determining absorption and toxicity of certain herbicides. Glyphosate absorption, translocation, and phytotoxicity to velvetleaf (*Abutilon theophrasti* Medik.) increased as concentration of glyphosate or surfactant (or both) in the droplet decreased [5,6]. Buhler and Burnside [2]

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found that glyphosate efficacy increased as spray volume decreased from 190 to 24 L/ha, and they attributed the increased efficacy to smaller spray droplets and higher glyphosate or surfactant concentration in the commercial glyphosate formulation with low spray volumes (or both). Similarly, glyphosate phytotoxicity to bermudagrass [*Cynodon dactylon* (L.) Pers.] increased as spray volume decreased from 370 to 47 L/ha, which was attributed to greater glyphosate and surfactant concentrations at low spray volumes [3]. Likewise, Ambach and Ashford [7] found that glyphosate phytotoxicity to barley (*Hordeum vulgare* L.) was greater with a single concentrated droplet than with a number of dilute droplets.

Much work has been done on the use of various spray volumes and spray tip with other herbicides, mainly glyphosate; however, no reports could be found that discussed spray volume and spray tip when using imazapic or imazethapyr which are herbicides that are commonly used in peanut production. Therefore, the objective of this research was to determine the influence of spray tips and spray volumes on weed efficacy when using imazapic and imazethapyr.

2. MATERIALS AND METHODS

2.1 Research Sites

Studies were conducted during the 2006 and 2007 growing seasons at Texas A&M AgriLife Research site near Yoakum in south Texas and at the Texas A&M AgriLife Research and Extension Center at Halfway in the Texas High Plains. Soil type at the Yoakum site was a Tremona loamy fine sand (thermic Aquic Arenic Palenstalf) with less than 1% organic matter and pH 7.2, while the soil type at Halfway was a Pullman clay

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loam (fine, mixed, thermic Torrertic Paleustoll) with less than 1% organic matter and pH 7.7.

2.2 Herbicides, spray tips, and spray volume

Imazapic and imazethapyr at 0.07 kg ai/ha was evaluated in four separate small-plot studies during the 2006 and 2007 growing seasons in the south Texas and in the High Plains of Texas peanut growing regions for weed control when using different spray tips and spray volumes. Spray tips (Spraying Systems Company, P.O. Box 7900, North Avenue, Wheaton, IL 60188) evaluated included 110015 flat fan (FF), 110015 Turbo TeeJet (TT), 110015 drift guard (DG), 110015 air induction (AI), 110015 extended range (XR), and 110015 turbo drop (TD). With this study, spray volume at the High Plains location was 93.5 L/ha while at the south Texas location, the spray volume was 187 L/ha. A crop oil concentrate (Agridex, a blend of 83% paraffin-based petroleum oil and 17% surfactant, Helena Chemical Company, Suite 500, 6075 Poplar Ave., Memphis, TN 38137) was included with all treatments at the rate of 1% (v/v).

The spray volume study was conducted with imazapic or imazethapyr at 0.07 kg ai/ha using Agridex at 1% (v/v). Spray volumes evaluated included 47, 71, 94, 117, 140, 164, and 187 L/ha applied with 11001DG spray tips using a CO_2 pressurized backpack sprayer in south Texas while in the High Plains herbicides were applied with a tractor-mounted compressed air small plot sprayer using 110015TT tips. Spray volume was regulated by varying ground speed such that a change in efficacy with spray volume was not attributed to droplet size.

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2.3 Weed populations and size at time of herbicide application

Weed ratings recorded 28 d after treatment are reported based on a scale of 0 (no control) to 100 (complete control). Weed populations for *A. palmeri* in 2006 and 2007 at the High Plains location were 24 to 30 plants/m^2 while *S. elaeagnifolium* and *P. louisianica* populations in 2006 and *T. terrestris* and *S. spinosa* populations in 2007 ranged from 2 to 5 plants/m^2. *T. terrestris* was present in high enough populations to evaluate in the spray volume but not the spray tip study. At the south Texas location, *U. texana* and *A. palmeri* were present at 6 to 8 plants/m^2 in 2006. In 2007 *D. ciliaris* populations were 4 to 6 plants/m^2 while *C. melo* and *I. lacunosa* populations were 8 to 10 plants/m^2.

At the time of herbicide application, *A. palmeri*, *P. louisianica*, *S. elaeagnifolium*, *S. spinosa*, *S. elaeagnifolium*, and *T. terrestris* were less than 16 cm tall at the High Plains location in both years while at the south Texas location, *A. palmeri*, *D. ciliaris*, and *U. texana* were less than 20 cm tall and *C. melo* and *I. lacunose* were less than 15 cm in length.

2.4 Plot size and experimental design

Peanut (Tamrun OL01) at 100 kg/ha was planted both years at the south Texas location but the area was fallow at the High Plains location. Each plot in south Texas was two rows 7.6 m long spaced 96 cm apart or 4 m wide by 15 m long at the High Plains location. In 2006 at the south Texas location, supplemental irrigation was applied as needed while in 2007 no irrigation was required due to above average rainfall. No supplemental irrigation was used at the High Plains location.

The experimental design was a randomized complete block with three replications and either a seven (spray volume) or five (spray tip) by two (imazapic or imazethapyr)

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factorial arrangement of treatments. Data for percentage of weed control were transformed to the arcsine square root prior to analysis; however, nontransformed means are presented because arscine transformation did not affect interpretation of the data. Treatment means were separated using Fisher's Protected LSD at $P \leq 0.10$. The nontreated control was included for visual comparison of weed control and was not included in any data analysis.

3. RESULTS AND DISCUSSION

3.1 Weed control with different spray volumes

For annual grass control there was a spray volume by year interaction while for *A. palmeri* control, there was a spray volume and herbicide by year interaction; therefore, these variables are presented separately. For *C. melo*, *S. elaegnifolium*, *P. louisianica*, *T. terrestris*, *I. lacunose*, and *S. spinosa*, which were present at one location, there was only a herbicide by spray volume interaction.

3.1.1 Annual grass control

In 2006, imazethapyr and imazapic applications with all spray volumes controlled *U. texana* at least 94% and only applications with the spray volume of 47 L/ha provided less control than 94 L/ha (Table 1). In 2007, herbicide applications with spray volumes of 94 L/ha or less controlled *D. ciliaris* at least 86% while applications with spray volumes of 117 L/ha or greater controlled 75% or less (Table 1). In another study, imazethapyr, nicosulfuron, and sethoxydim with methylated vegetable oil applied on an area basis were equally or more effective when applied in 37 to 75 L/ha than in 94 to 187 L/ha [8]. Ramsdale and Nalewaja [9] reported that high herbicide concentrations increased

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imazethapyr absorption when sufficient adjuvant was present. Absorption also increased as herbicide concentration increased for glyphosate, sethoxydim, fluazifop-butyl, and haloxyfop-methyl [2,5,6].

When imazapic was compared with imazethapyr for annual grass control, no difference in *U. texana* or *D. ciliaris* control was noted with either herbicide in 2006 or 2007 (Table 2). In 2006, imazapic and imazethapyr controlled *U. texana* at least 96% while in 2007 both herbicides provided no better than 74% control of *D.ciliaris*. In a previous study evaluating POST herbicides, imazapic controlled *U. texana* at least 80% when used without a soil-applied herbicide [10]. The imidazolinone herbicides usually provide partial control of annual grasses (author's personal observation). Imazethapyr, when soil-applied, will provide virtually no annual grass control; however, imazapic applied POST will control *U. texana* 60 to 70% and will provide greater than 90% control of *D. ciliaris* and *Brachiaria platyphylla* [Griseb.] when applied to grasses less than 3 cm tall [10]. The use of a dinitroaniline herbicide with either imazapic or imazethapyr improved *U. texana* control over the dinitroaniline herbicide alone [11].

3.1.2 *Amaranthus palmeri* control

In 2006, at the High Plains location, imazethapyr and imazapic applications at any spray volume provided no better than 65% *A. palmeri* control (Table 1). Applications at spray volumes of 47 to 94 L/ha controlled *A. palmeri* 57 to 65% while applications at spray volumes of 117 to 187 L/ha controlled no better than 50%. At the south Texas location, herbicide applications at all spray volumes controlled *A. palmeri* at least 98%. In 2007, at the High Plains location, herbicides applied at the spray volume of 187 L/ha controlled less *A. palmeri* than applications at a spray volume of 47, 71, 117, and 140 L/ha.

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The improved control of *A. palmeri* at the south Texas location may be due to higher air temperatures and relative humidities during the June to August growing period when herbicides were applied (data not shown). Typically, air temperatures in south Texas during this time period in the daytime range from 32 to 38° C while nighttime temperatures seldom fall below 27^{0} C. Also, relative humidity usually ranges from 75 to 90% (author's personal observation). Daytime temperatures in the High Plains may be similar but temperatures typically fall to less than 27° C during the nightime while the relative humidity rarely gets above 40% (author's personal observations). Air temperature and relative humidity directly influence herbicide absorption and translocation in plants [12]. In general, the uptake and translocation of most POST herbicides increases with rising temperature and humidity [12]. Relative humidity enhances the absorption and translocation of herbicides in plants by prolonging the drying of the spray droplets on the leaf surface, increasing cuticle hydration, and to a smaller extent by favoring stomatal opening [13].

In 2006, at the High Plains location, there was a difference in *A. palmeri* control between imazapic and imazethapyr; however, both levels of control were unacceptable (less than 60%) and at the south Texas location both herbicides provided at least 99% control (Table 2). In 2007 at the Southern High Plains location both herbicides provided 73 to 75% control (Table 2). In earlier work by Grichar [14], imazapic at 0.04 to 0.07 kg/ha controlled *A. palmeri* at least 95% when applied early postemergence (EPOST) while imazethapyr provided at least 90% control in 2 of the 3 yr.

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3.1.3 *Proboscidea louisianica* control

No herbicide or applications with any spray volume controlled *P. louisianica* more than 63% (Table 3). Imazapic applied at 94 or 187 L/ha (> 62 to 63%) and imazethapyr applied at either 47 or 94 L/ha (57%) provided the best control for each of the herbicides. Thompson et al. [15] reported that imazapic at 0.04 to 0.07 kg/ha controlled *P. louisianica* 88 to 94% when applied EPOST or late postemergence (LPOST).

3.1.4 *Solanum elaeagnifolium* control

No herbicide or applications with any spray volume controlled *S. elaeagnifolium* greater than 65% (Table 3). Imazapic (65%) and imazethapyr (57%) applied at a spray volume of 94 L/ha provided the best control for each herbicide. No data could be found on using imazapic or imazethapyr to control silverleaf nightshade.

3.1.5 *Tribulus terrestris* control

With all spray volumes, imazapic provided better *T. terrestris* control than imazethapyr (Table 3). No data could be found for puncturevine control when using imazapic or imazethapyr. However, Geier et al. [16] reported that *S*-metolachlor alone provided variable *T. terrestris* control which ranged from 70 to 99%, while the addition of atrazine to *S*-metolachlor provided more consistent control of 95 to 100%.

3.1.6 *Cucumis melo* control.

Both imazapic and imazethapyr controlled *C. melo* at least 97% when applied at 94 L/ha or less (Table 3). However, when the spray volume was increased to 117 L/ha or greater, *C.melo* control with both imazapic and imazethapyr was no greater then 80% with the exception of imazethapyr applied at 187 L/ha and imazapic applied at 117 L/ha which

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controlled *C. melo* 90 and 100%, respectively. *C. melo* is becoming more of a problem in south Texas peanut production fields and has become a problem in several crops along the Texas Gulf coast (author's personal observation). *C. melo* can be a problem at peanut harvest as the melon can become broken apart when run through the combine and increase drying time because of the high moisture content of the melon itself (author's personal observation). In corn (*Zea mays* L.), Thompson et al. [15] reported that imazapic at 0.07 and 0.14 kg/ha applied preemergence (PRE), EPOST, or LPOST controlled *C.melo* greater than 90%.

3.1.7 *Ipomoea lacunose* control.

Both imazapic and imazethapyr controlled *I. lacunose* at least 98% when applied at a spray volume of 94 L/ha or less (Table 3). Imazapic applied at a spray volume of 117 L/ha controlled *I. lacunose* 99%, but imazethapyr at this spray volume provided only 77% control. When imazapic was applied at a spray volume of 140 to 187 L/ha, *I. lacunose* control was 78 to 87% while imazethapyr at these same spray volumes provided 83 to 94% control. Imazapic and imazethapyr provided excellent *Ipomoea* spp. control [17,18]. Grichar [17] reported that imazapic at 0.04 and 0.07 kg/ha provided at least 80% *I. lacunose* control with EPOST and POST applications. In other studies, imazapic at 9 g/ha has provided *I. lacunose* control which varied from 33 to 85% [19]. Research by Wilcut et al. [20] found that imazapic was more effective at controlling *I. lacunose* than imazethapyr applied either PPI, PRE, or early POST.

3.1.8 *Sida spinosa* control.

S. spinosa was controlled no less than 99% when applied at a spray volume of 47 to 94 L/ha (Table 3). At a spray volume of 117 L/ha, imazapic controlled prickly sida 100%

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while imazethapyr provided only 67% control. At spray volumes at 140 L/ha or higher, only imazethapyr applied at a spray volume of 164 L/ha or imazapic at a spray volume of 187 L/ha provided at least 85% control. *S. spinosa* is mainly a problem in the southeastern peanut growing region [20]. Bentazon and imazethapyr POST will control *S. spinosa* when applied to small sized plants, but if larger than two-leaf, imazethapyr POST was found to be ineffective [20]. Wilcut [21] noted that imazapic controlled five-leaf *S. spinosa* at least 95%.

3.2 Weed control with different spray tips.

For annual grass and *A. palmeri* control, there was either no spray tip or herbicide by year interaction; therefore, these variables are presented separately. For *C. melo*, *I. lacunose*, *P. louisianica*, *S. elaeagnifolium*, and *S. spinosa* there was no spray tip by herbicide interaction; therefore, these variables are presented separately.

3.2.1 Annual grass control.

No difference in *U. texana* (2006) or *D. ciliaris* (2007) control was noted between the different spray tips (Table 4). *U. texana* control varied from 87 to 100% while *D. ciliaris* control varied from 66 to 78%.

In both years, imazapic provided better annual grass control than imazethapyr (Table 5). In 2006, imazapic controlled 100% *U. texana* while imazethapyr provided 89% control and in 2007, imazapic provided 85% *D. ciliaris* control while imazethapyr only controlled 59% (Table 5).

3.2.2 *A. palmeri* control.

At the High Plains location in 2006, poor (27 to 69%) *A. palmeri* control was noted with all spray tips (Table 4). *A. palmeri* was controlled 61 to 69% when FF, TT, and DG

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spray tips were used, while control with AI and XR tips was less than 50%. At the south Texas location, *A. palmeri* was controlled at least 98% with all spray tips.

In 2007at the High Plains location, *A. palmeri* was controlled 72 to 79% with all spray tips (Table 4**).** No difference in *A. palmeri* control was noted in 2006 between imazapic and imazethapyr at either location; however, at the southern High Plains location in 2007 imazapic provided better control than imazethapyr (Table 5).

3.2.3 *C. melo* control.

C. melo was controlled at least 95% with all spray tips regardless of herbicide (Table 6). Imazapic controlled *C. melo* better than imazethapyr (Table 7). Grichar [22], in a two year study in peanut, reported that imazapic controlled *C. melo* 86 to 89% while imazethapyr controlled smellmelon 61 to 76%.

3.2.4 *I. lacunose* control.

No difference in *I. lacunose* control was noted with any spray tip (Table 6) and imazapic provided better control than imazethapyr (Table 7). Imazapic and imazethapyr have provided excellent *Ipomoea* spp. control [17,18,23]. Grichar [17] reported that imazapic at 0.04 and 0.07 kg/ha provided at least 80% *I. lacunosa* control with early POST and POST applications while Newsom and Shaw [19] reported imazapic at 9 g/ha provided *I. lacunose* control which varied from 33 to 85%. Wilcut et al. [20] reported that imazapic was more effective than imazethapyr applied either PPI, PRE, or early POST.

3.2.5 *P. louisianica* control.

The FF spray tips provided better control (65%) of *P. louisianica* than the AI or XR spray tips (Table 6). No difference in control was noted between imazapic and imazethapyr (Table 7). In earlier work, Grichar et al. [24] reported that ethalfluralin alone did not

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control *P. louisianica*; however, ethalfluralin followed by imazapic applied POST provided 100% control. In commercial fields, imazapic has provided excellent *P. louisianica* control [25].

3.2.6 *S. elaeagnifolium* control.

S. elaeagnifolium control was 62% or less with all spray tips (Table 6). The TT spray tip provided better control than all other tips. No difference in silverleaf nightshade control was noted between imazapic and imazethapyr (Table 7).

3.2.7 *S. spinosa* control.

No difference in *S. spinosa* control was noted with any spray tip with control ranging from 68 to 77% (Table 6). Imazapic provided perfect control while imazethapyr controlled only 43% (Table 7). Previously, Ducar et al [26] reported 99 to 100% control of *S. spinosa* in corn with imazapic at 0.035 and 0.07 kg/ha, respectively.

4. CONCLUSION

In south Texas under extremely dry conditions (2006), supplemented by irrigation, spray volume had no effect on *U. texana* control. However, in an above average rainfall year (2007), herbicide efficacy on *D. ciliaris* decreased as spray volume was increased above 94 L/ha. Control of *C. melo* and *I. lacunose*, and also decreased as spray volume increased. No response to spray volume was noted at the High Plains location with the exception of *S. spinosa* and *T. terrestris* and this may be due to lower humidities which are generally found in this area. Several studies have reported that spray volume did not influence *Cyperus esculentus* L. control [27,28]. In contrast, low spray volumes increased annual grass control with glyphosate [2]. Other studies have reported that

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herbicide efficacy in low spray volumes is often dependent on the specific adjuvant and adjuvant amount. Conversely, herbicide efficacy generally increased as spray volume increased when adjuvants were applied as a percentage of spray volume [9,29].

Also, relative humidity can directly influence herbicide absorption and translocation in plants [12]. Relative humidity enhances the absorption and translocation of herbicides in plants by prolonging the drying of the spray droplets on the leaf surface [12], increasing cuticle hydration [13], and to a smaller extent by favoring stomatal opening [13]. This may explain why there was little or no difference in herbicide efficacy under the low humidity conditions of the High Plains or south Texas in 2006; however, under the high humidity conditions observed in south Texas during the 2007 growing season, differences in weed control were noted.

Standard low-input nozzles typically used for low volume applications have a small orifice that is subject to plugging and produce fine spray droplets that are susceptible to spray drift. These nozzle characteristics have deterred the use of low spray volumes, even though low volumes are known to be effective with certain herbicides [30]. However, drift-reducing nozzles that produce large spray droplets at low spray volumes were equally as effective as the standard low output nozzles in enhancing glyphosate efficacy [1].

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Table 1. Annual grass and *A. palmeri* control 4 weeks after treatment when using different spray volumes averaged over imazapic or imazethapyr treatments.[a,b]

	A. palmeri

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Spray volume	Annual grass[c]		2006		2007
L/ha	2006	2007	High Plains	South Texas	High Plains
	%				
47	94	86	65	99	72
71	99	91	57	99	74
94	100	97	64	100	71
117	96	75	44	98	74
140	99	52	50	99	72
164	99	58	47	99	70
187	98	58	47	100	65
LSD (0.10)	5	14	13	NS	7

[a] No herbicide by spray volume interaction; therefore, data presented separately by spray volume.
[b] 11001DG spray tip used at the south Texas location while 110015TT spray tip used at the High Plains location.
[c] *Urochloa texana* present in 2006 with *Digitaria ciliaris* present in 2007.

Table 2. Annual grass and *A. palmeri* control 4 weeks after treatment when using imazapic or imazethapyr averaged over spray volumes.[a,b]

			A. palmeri		
	Annual grass[d]		2006		2007
Herbicide[c]	2006	2007	High Plains	South Texas	High Plains
	%				
Imazapic	100	74	59	100	75
Imazethapyr	96	73	48	99	73
LSD (0.10)	NS	NS	7	NS	NS

[a] No herbicide by spray volume interaction; therefore, data presented separately by herbicide.
[b] Spray tip 11001DG used at the south Texas location while spray tip 110015TT used at the High Plains location.

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[c] Imazapic and imazethapyr dose was 0.07 kg/ha.
[d] *Urochloa texana* present in 2006 with *Digitaria ciliaris* present in 2007.

Table 3. Broadleaf weed control with imazapic and imazethapyr when applied at different spray volumes.[a]

		Broadleaf weeds					
Spray volume	Herbicide[b]	PROLO	SOLEL	TRBTE	CUMME	IPOLA	SIDSP
L/ha		%					
47	Imazapic	50	50	97	99	98	100
	Imazethapyr	57	37	87	99	98	100
71	Imazapic	58	45	98	99	98	99
	Imazethapyr	52	45	87	97	99	100
94	Imazapic	63	65	100	99	99	100
	Imazethapyr	57	57	88	100	98	100
117	Imazapic	50	40	100	100	99	100
	Imazethapyr	28	35	93	77	77	67
140	Imazapic	57	52	95	70	80	63
	Imazethapyr	45	45	85	80	90	57
164	Imazapic	57	40	95	75	87	57
	Imazethapyr	43	40	72	70	83	96
187	Imazapic	62	53	75	77	78	85
	Imazethapyr	53	55	67	90	94	77
LSD (0.10)		12	12	9	10	13	24

[a] Bayer code for weeds: PROLO, *Proboscidea louisianica*; SOLEL, *Solanum elaeagnifolium*;

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TRBTE, *Tribulus terrestris*; CUMME, *Cucumis melo*; IPOLA, *Ipomoea lacunose*; SIDSP, *Sida spinosa*.
[b] Imazapic and imazethapyr dose was 0.07 kg/ha.

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Table 4. Annual grass and *A. palmeri* control 4 weeks after treatment averaged over imazapic or imazethapyr treatments when using different spray tips.[a,b]

			A. palmeri		
	Annual grass[d]		2006		2007
Spray tips[c]	2006	2007	High Plains	South Texas	High Plains
	%				
110015FF	98	74	61	99	73
110015TT	91	66	69	99	72
110015DG	87	76	65	100	73
110015AI	100	78	47	98	79
110015TD	97	68	-	99	-
110015XR	-	-	27	-	73
LSD (0.10)	NS	NS	16	NS	NS

[a] No herbicide by spray tip interaction; therefore, data presented separately by spray tip.
[b] Spray volume in south Texas was 187 L/ha while 93.5 L/ha was used at the High Plains location.
[c] Abbreviations: FF, flat fan; TT, turbo teejet; DG, drift guard; AI, air induction; TD, turbo drop; XR, extended range.
[d] *Urochloa texana* present in 2006 while *Digitaria ciliaris* present in 2007.

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Table 5. Annual grass and *A. palmeri* control 4 weeks after treatment when using imazapic or imazethapyr averaged over spray tips.[a,b]

			A. palmeri		
	Annual grass[d]		2006		2007
Herbicide[c]	2006	2007	High Plains	South Texas	High Plains
	%				
Imazapic	100	85	60	100	75
Imazethapyr	89	59	48	99	72
LSD (0.10)	2	20	NS	NS	2

[a] No herbicide by spray tip interaction; therefore, data are presented separately by herbicide.
[b] Spray volume in south Texas was 187 L/ha while 93.5 L/ha was used at the High Plains location.
[c] Imazapic and imazethapyr dose was 0.07 kg/ha.
[d] *Urochloa texana* present in 2006 with *Digitaria ciliaris* present in 2007.

Table 6. Weed control 4 weeks after treatment when using different spray tips averaged over imazapic or imazethapyr treatments.[a,b]

Spray tips[c]	Weeds[d]				
	CUMME	IPOLA	PROLO	SOLEL	SIDSP
	%				
110015FF	96	95	65	46	73
110015TT	96	87	51	62	77
110015DG	95	81	48	57	70
110015AI	97	96	45	42	68
110015TD	96	95	-	-	70
110015XR	-	-	40	45	-
LSD (0.10)	NS	NS	20	12	NS

[a] No herbicide by spray tip interaction; therefore, data presented separately by spray tip.
[b] Spray volume in south Texas was 187 L/ha while 93.5 L/ha was used at the High Plains location.
[c] Abbreviations: FF, flat fan; TT,turbo teejet; DG, drift guard; AI, air induction; TD, turbo drop; XR, extended range.
[d] Bayer code for weeds: IPOLA, *Ipomoea lacunose*; CUMME, *Cucumis melo*; SIDSP, *Sida spinosa*; SOLEL, *Solanum elaeagnifolium*; PROLO, *Proboscidea louisianica*.

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Table 7. Broadleaf weed control 4 weeks after treatment when using imazapic or imazethapyr averaged over spray tips.[a,b]

	Weeds[d]				
Herbicide[c]	CUMME	IPOLA	PROLO	SOLEL	SIDSP
	%				
Imazapic	99	94	49	52	100
Imazethapyr	93	87	50	49	43
LSD (0.10)	4	1	NS	NS	17

[a] No herbicide by spray tip interaction; therefore, data presented separately by herbicide.
[b] 11001DG spray tip was used at the south Texas location while 110015TT spray tip was used at the High Plains location.
[c] Imazapic and imazethapyr dose was 0.07 kg/ha.
[d] Bayer code for weeds: IPOLA, *Ipomoea lacunose*; CUMME, *Cucumis melo*; SIDSP, *Sida spinosa*; SOLEL, *Solanum elaeagnifolium*; PROLO, *Proboscidea louisianica*.