EVALUATION OF NEW AND GENERIC HERBICIDES FOR ODOT ROADSIDE VEGETATION MANAGEMENT PROGRAMS

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MODERN METRIC CONVERSION FACTORS*

APPROXIMATE CONVERSIONS TO SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
A	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	A
km^2	square kilometers	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
^oC	Celsius	1.8C+32	Fahrenheit	^oF
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

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1.0 INTRODUCTION

Johnsongrass (*Sorghum halepense*) and several other roadside weeds are more competitive when less frequent mowing of roadsides is practiced (1). In such programs these weeds may frequently exceed the 12 inch maximum vegetation height prescribed in state mowing manuals such as that of ODOT. An integrated program of mowing and herbicide use is practiced to manage undesirable plants in the clear zone. Additionally, there are portions of the right of way in which vegetation managers desire no vegetation. As an example, some managers desire to not have any vegetation in the cross over cable barrier footprint while others desire to have a dense, perennial vegetation in the footprint. In either case, undesirable weeds can be present in the footprint which requires management through combined mowing, string trimming and herbicide use.

While development of agrichemical herbicides has slowed for agricultural crops, there is a sustained interest by the agrichemical manufacturers and marketers to expand herbicide label registrations on existing products into the industrial and roadside vegetation management market. The development of new herbicide products increases market competition and can result in reduced product prices to end users.

This report covers research trials conducted during the 2012 growing season. These trials focused on i) the continued development of herbicide tank mix combinations for control of weeds in the cable-barrier footprint (Chapters 2, 3, and 4) and ii) evaluation of new postemergent herbicide treatment combinations for summer annual broadleaf and grassy weed control (Chapter 5).

Streamline™ (2) and Perspective™ (3) herbicides received their USEPA registration in 2011 and should provide increased kochia and field bindweed control for ODOT personnel across the state (4). This year's research continued the effort to develop long-term residual weed control treatments for the cable-barrier footprint as requested by ODOT field staff. Developing a successful cable-barrier weed control program while meeting field division goals and maintaining environmental sensitivity can be challenging. Many vegetation managers desire season-long vegetation control from a single herbicide application. However our previous findings suggest a successful cable-barrier weed control program will involve at least two seasonal herbicide applications. In all likelihood an early tank mix application of a preemergence and postemergence treatment followed by a summer postemergence treatment will be necessary to keep gravel or asphalt milling-based cable-barrier footprints void of all or nearly all vegetation. None the less, research continued in 2012 for the elusive "season-long" weed control treatment that also has a suitable environmental impact profile. Research is needed to continue development of the herbicide components necessary to provide ODOT field divisions with programs that provide acceptable levels of weed control for the wide variety of cable-barrier installations.

In addition to original planned research, some unplanned research was conducted in 2012 following our OSU RVM Program being approached by Bayer Crop Science corporation to examine several new postemergence herbicides of possible interest to ODOT for use in roadside weed control programs. The new herbicides from Bayer are currently labeled in many agricultural and turf use sites but are new to industrial vegetation management areas.

2.0 EVALUATION OF SELECTED HERBICIDE COMBINATIONS FOR THEIR ABILITY TO PROVIDE LONG-TERM RESIDUAL WEED CONTROL (STUDY 4-H-11-12)

2.1 BACKGROUND

When early cable barrier systems were installed in Oklahoma it was common for many ODOT vegetation managers to try to achieve total vegetation control in the foot print under the barrier. Total vegetation control means the maintenance of a vegetation-free (bareground) area in the footprint under the barriers. The barriers might be located in the center median ditch bottom, or upslope with the barrier footprint located in asphalt millings or in the asphalt shoulder. Some ODOT personnel quickly found that on sloped sites where the cable barrier footprint is principally soil or small diameter crushed rock, a “bareground herbicide treatment” often resulted in moderate to severe soil erosion. Because of the erosion, many ODOT personnel began to see the benefit in maintaining common bermudagrass instead of bareground in the cable barrier footprint. Whether the goal is to maintain bareground or weed-free common bermudagrass under a cable barrier, these sites are subject to constant weed invasion and therefore need a management program.

The herbicides chosen for screening in this study were considered to be “soft” residual herbicides that have a suitable environmental risk and that provide potential for long-term weed control in either a bareground or common bermudagrass system. The herbicides/rates utilized have not been associated with high runoff potential or down slope movement and damage to off-target vegetation. The purpose of investigation of these particular treatments was to determine if they provided consistent season-long annual weed control when applied in a late-winter/early-spring time frame. 2012 work represents the second year of focus on this particular initiative.

2.2 OBJECTIVE

The objective of this study was to evaluate 15 herbicide treatments for preemergence weed control during the course of the 2012 growing season.

2.3 MATERIALS AND METHODS

This study was located at the Oklahoma State University Cimarron Valley Research Station in Perkins, Oklahoma. Specific trial details are shown in Table 1. The soil type on the test site was a Teller series loam (5). The trial area was prepared by treating with

Roundup Pro Concentrate (6) at 2 qts. product/Acre on February 1, 2012 by the Cimarron Valley Research Station staff. This action was taken to control existing winter annual weeds. It facilitated the screening of preemergent herbicide treatment

Table 1. Herbicide application specifics for experiment 4-H-11-12.

Application Factor	**Measurement**
Application Date:	Mar-5-2012
Time of Day:	7:20 a.m.
Plot size:	5 feet X 15 feet (with 3 foot paired check)
Application Method:	Broadcast spray
Application Timing:	Preemergence & Postemergence
Application Placement:	Soil & foliar
Air Temperature:	45 F
Relative Humidity:	58 %
Wind Velocity:	4 MPH
Wind Direction:	W
Dew Presence (Y/N):	No
Soil Temperature:	47 F
Soil Moisture:	Good
Cloud Cover:	0 %
Appl. Equipment:	4-wheel ATV
Operating Pressure:	25 PSI
Nozzle Type:	Teejet
Nozzle Size:	8004VS
Nozzle Spacing, Unit:	20 inches
Nozzles/Row:	3
Boom Height:	20 inches
Ground Speed:	2.5 MPH
Carrier:	Water
Spray Volume:	30 gallons per acre
Mix Size:	1.8 liters
Propellant:	CO2

combinations for summer annual weed control to be conducted later. On February 1 the winter annual weeds present were annual ryegrass [*Lolium multiflora*], henbit [*Lamium amplexicaule*], sheperdspurse [*Capsella bursa pastoris*], hairy vetch [*Vicia villosa*], and cutleaf evening-primrose [*Oenothera laciniata*]. The research area was overseeded with palmer amaranth [*Amaranthus palmeri*] seed on February 27, 2012. Seed was purchased in 2011 from Azlin Seed Service (10) of Leland, MS. Palmer amaranth seed was distributed at a rate of 8.0 pounds per acre using a handheld Groundworks Broadcast spreader.

While the control of all existing winter annual vegetation was fairly successful following the February 1 preparation treatment, an additional spot broadcast treatment of

Roundup Pro Concentrate at 1.0 qt. product/Acre was applied on March 5 at the initiation of the trial to control weeds that were in areas that had been inadvertently skipped during the February 1 cleanup by station staff.

Table 2 shows the herbicide treatments investigated for summer annual weed control performance. The application of the glyphosate component on March 5 was critical for those herbicide treatments under study (Table 2) that only have preemergence activity. Those having only preemergent activity included Gallery® (a.i. isoxaben) (7), Prodiamine 65WDG (a.i. prodiamine) (8), and Pendulum® (a.i. pendimethalin) (9).

Within 6 days of the March 5 herbicide trial treatment date this study received two rainfall events that totaled 1.75 inches (11). These rains should have provided adequate water to activate all herbicides in this study. No summer annual weed species were emerged at the time of herbicide treatment. Preemergence weed control evaluations were taken on the summer annual weeds palmer amaranth, large crabgrass [*Digitaria sanguinalis*], marestail [*Hippuris vulgaris*], and carpetweed [*Mollugo verticilata*], and the winter annual weed cutleaf evening-primrose. Preemergence weed control data was collected monthly for each of the summer weed species through 8 months after treatment (MAT). Agricultural Research Manager Software (ARM) was used to conduct an Analysis of Variance (ANOVA) procedure on the data and when the treatment effect was found significant at the 90% certainty level (p=0.10) means were separated with Fishers Least Significant Difference (LSD) test.

2.4 RESULTS AND DISCUSSION

At 63 DAA (Table 2) all treatments were providing good to excellent control of palmer amaranth with the exception of Oust Extra alone and Milestone VM alone. At the time of the 98 DAA evaluations all treatments were producing excellent (95% or greater) control of palmer amaranth with the exception of the treatments Oust Extra alone, Milestone VM alone, and Milestone VM plus Oust Extra. Palmer amaranth control continued to decline for each of these three treatments. At 119 DAA all remaining treatments continued to produce excellent control of palmer amaranth with the exception of Plainview which was allowing a few palmer amaranth plants to break through the chemical barrier. At the final evaluation date for palmer amaranth control, some 186 DAA, the treatments of Diuron alone, Diuron plus Oust Extra, and indaziflam plus Oust Extra were maintaining complete control of palmer amaranth. Treatments of Gallery plus Oust Extra, indaziflam alone, prodiamine plus Roundup Pro Concentrate, Pendulum plus Roundup Pro Concentrate, Streamline, and Perspective were all continuing to produce excellent palmer amaranth control (96% or greater).

Most treatments in this study provided excellent control of the summer annual weed large crabgrass for the entire season (Table 3). At the time of the 63 and 98 DAA evaluations all treatments were producing complete control or near complete control of large crabgrass with the exception of Milestone VM alone. At 119 DAA, all treatments were producing excellent control (95% or greater) of large crabgrass with the exception of Milestone VM. A similar trend continued at the final 186 DAA evaluations with

Milestone VM showing very little activity on large crabgrass. At that time the treatment of Oust Extra alone was allowing for a small amount of large crabgrass to break through the chemical barrier. With respect to weed control treatments such as those examined in this study, weed control levels of 95% may or may not be acceptable to ODOT personnel desiring complete vegetation control. Allowing just five percent of the weeds to break through a treatment may result in ODOT having to make a spot treatment or possibly send out a weed-eater crew to take care of escaped weeds.

Marestail populations were low and erratic within the study area. However, attempts were made to collect some level of useful control data or observations. Treatments that seemed to provide excellent marestail control throughout the duration of this study were Oust Extra alone, Diuron alone, Diuron plus Oust Extra, Gallery plus Oust Extra, Milestone VM, Milestone VM plus Oust Extra, indaziflam plus Oust Extra, Plainview, Streamline, and Perspective (Table 4). Each of these treatments maintained complete or near complete control of marestail. Other treatments provided for varying levels of marestail control and suppression, which was erratic amongst treatment replications. Some of the erratic responses of treatments are explainable. We believe they are due to highly variable amounts of weed pressure from marestail within the study area. However, much of the erratic control was likely due to the response of marestail to the different herbicides. The treatments containing dinitroanaline herbicides, which included prodiamine and Pendulum (active ingredient pendimethalin) herbicides, provided only fair to poor control of marestail.

Carpetweed was also present within the study area. While not considered to be a troublesome weed in the roadside clearzone (due to its very low growing height), it might be considered a troublesome weed under a cable barrier if one desires complete vegetation control. At 63 DAA all treatments, excluding Milestone VM, were providing for complete control of carpetweed (Table 5). At 98 DAA all treatments were maintaining complete or near complete control of carpetweed with the exception of Milestone VM and Pendulum. At 119 DAA several treatments were beginning to show signs of allowing carpetweed to break through the chemical barrier. Treatments of Gallery alone, indaziflam alone, prodiamine, and Pendulum were all producing fair to poor control of carpetweed. At this time all other treatments were maintaining excellent control of carpetweed. At the time of the final 186 DAA evaluations, and after many of the existing carpetweeds had burned up during mid to late summer conditions, all treatments excluding Gallery alone and Milestone VM alone were maintaining excellent control of late-season emerging carpetweed.

Ratings for the percentage of area having no vegetation present (bareground) were made 248 DAA at the end of the annual growing season during November (Table 6). At that time there were no treatments that were producing complete control of all vegetation. However, treatments of Diuron alone, Diuron plus Oust Extra, Gallery plus Oust Extra, indaziflam plus Oust Extra, and Perspective were producing excellent control of all existing vegetation and producing 97% or greater bareground levels.

2.5 CONCLUSIONS

The treatments investigated in this trial over the two year period are ones that we feel have suitable environmental risk profiles when used for complete vegetation control of summer annuals in the cable barrier foot print on slopes and in the bottoms of the median ditch. The treatments of Diuron plus Oust Extra, indaziflam plus Oust Extra, and Perspective plus Oust XP have provided the highest, most consistent level of control of summer annuals (bareground) by the end of each growing season during the two years of trials conducted at the Cimarron Valley Research Center. These specific treatments have been able to produce and maintain at least 97% control of each of the annual weed species present at this site. Several of the other treatments evaluated in this study have also produced successful levels of weed control for some species but not for others. Some performed well under conditions of slight to moderate drought (2012) but failed under extreme drought (2011) on the site. Inconsistent weed control results will likely prevent many of these herbicides and combinations from becoming a successful bareground treatment. Some of these treatments may produce more consistent control levels than seen in the two years of this trial if they are combined with other herbicide tank mix partners. But under inconsistent rainfall they can be expected to perform inconsistently. Even the best performing treatments in this study appear to require a mid to late summer spot application of glyphosate in order to control weed escapes and maintain complete vegetation control (bareground). ODOT personnel should plan on making a mid to late summer spot application of glyphosate following all early applied residual treatments that are applied with the intent of having season long complete vegetation control.

The goal of the 2011 and 2012 trials at the Cimarron Valley Research Center (CVRC) was to develop season-long residual herbicide program recommendations using a single application for the control of summer annual weed species. However, ODOT personnel should keep in mind that one of the more common vegetation types that are encroaching into cable barrier footprints is common bermudagrass. Common bermudagrass is an aggressive perennial species that is desirable as a vegetation type on most roadside right of ways. However, if an ODOT manager desires the complete absence of vegetation in the cable-barrier footprint, bermudagrass is considered a weed. Common bermudagrass will not be controlled by any of the herbicide treatment combinations at the rates evaluated in the two years of trials conducted at the CVRC. Common bermudagrass, along with other perennial plant/weed species, will require some type of postemergence application in early to mid summer to control these specific weed types. Control of common bermudagrass may be desirable under some cable barriers, but under cable barriers on steeper slopes, or in the bottom of drainage ways, common bermudagrass should be allowed to spread to prevent soil erosion.

2.6 RECOMMENDATIONS

It is important to continue to develop cable barrier weed control treatments that meet the different goals of ODOT personnel. Whether the goal is complete vegetation control (bareground) or the management of a common bermudagrass turf in the cable barrier foot print (termed a “bermudagrass release program”) it is unlikely that a single herbicide treatment combination of a type with suitable environmental risk characteristics will be able to supply the necessary season-long weed control for the various field divisions. Recommendations for continued research and development of a cable barrier weed control program for ODOT include developing a safe mid to late summer spot treatment option to compliment the three long-term residual weed control treatments (Diuron plus Oust Extra, indaziflam plus Oust Extra, and Perspective plus Oust XP) that have provided the best, most consistent weed control in these studies. In the development of the spot treatment, both annual weed escapes and perennial grass control need to be addressed. As mentioned this could possibly result in two to four different treatment combinations being developed to specifically address the various ODOT cable barrier vegetation goals that exist within the various ODOT Field Divisions.

Table 2. Comparison of long-term residual herbicide combinations for preemergence control of palmer amaranth in Study 4-H-11-12.

Pest Name				% Palmer Amaranth Control							
Rating Date				5/7/2012		6/11/2012		7/2/2012		9/7/2012	
Trt-Eval Interval				63 DAA[1]		98 DAA		119 DAA		186 DAA	
Trt No.	Treatment Name	Rate	Rate Unit								
1	Untreated Check			0		0		0		27	
2	Oust Extra	5.13	oz wt/a	33	c	7	c	7	d	23	d
3	Diuron	8	lb/a	100	a	100	a	100	a	100	a
4	Diuron Oust Extra	5 4	lb/a oz wt/a	100	a	100	a	100	a	100	a
5	Gallery	1.33	lb/a	100	a	100	a	96	ab	89	ab
6	Gallery Oust Extra	1 4	lb/a oz wt/a	100	a	99	a	97	a	99	a
7	Milestone VM	7	fl oz/a	85	b	82	b	77	c	71	c
8	Milestone VM Oust Extra	5 4	fl oz/a oz wt/a	92	ab	83	b	77	c	80	bc
9	indaziflam	5	oz/a	99	a	100	a	100	a	99	a
10	indaziflam Oust Extra	5 4	oz/a oz wt/a	100	a	100	a	100	a	100	a
11	Prodiamine Roundup Pro Concentrate	2.3 25	lb/a fl oz/a	100	a	100	a	100	a	98	a
12	Pendulum Aquacap Roundup Pro Concentrate	4.8 25	qt/a fl oz/a	100	a	100	a	100	a	99	a
13	MAT28 (Plainview 10 oz.) Oust XP Telar XP	6.24 2.5 1.25	oz wt/a oz wt/a oz wt/a	98	a	95	a	88	b	93	a
14	MAT28 (Streamline 8 oz.) Escort XP Oust XP	6.3 1.68 3	oz wt/a oz wt/a oz wt/a	99	a	97	a	93	ab	96	a
15	MAT28 (Perspective 8 oz.) Telar XP Oust XP	6.3 2.1 3	oz wt/a oz wt/a oz wt/a	99	a	99	a	95	ab	98	a
LSD[2] (P=.10)				10.5		6.9		8.9		12.3	
Standard Deviation				7.5		5		6.4		8.9	
CV				8.09		5.54		7.27		9.96	
Replicate F				1.236		1.346		1.478		1.477	
Replicate Prob(F)				0.3071		0.2778		0.2466		0.2469	
Treatment F				16.616		73.987		45.051		16.476	
Treatment Prob(F)				0.0001		0.0001		0.0001		0.0001	

[1] DAA = days after application. [2]LSD = least significant difference test. Means sharing a common letter do not significantly differ at p = 0.10. NS = no significant differences present at p=0.10. Untreated checks were not included in the statistical analysis but their performance means are shown for comparative purposes.

Table 3. Comparison of long-term residual herbicide combinations for preemergence control of large crabgrass in Study 4-H-11-12.

Pest Name				% Large Crabgrass Control							
Rating Date				5/7/2012		6/11/2012		7/2/2012		9/7/2012	
Trt-Eval Interval				63 DAA[1]		98 DAA		119 DAA		186 DAA	
Trt No.	Treatment Name	Rate	Rate Unit								
1	Untreated Check			0		0		0		0	
2	Oust Extra	5.13	oz wt/a	99	a	98	a	95	a	96	a
3	Diuron	8	lb/a	100	a	100	a	100	a	100	a
4	Diuron Oust Extra	5 4	lb/a oz wt/a	100	a	100	a	100	a	100	a
5	Gallery	1.33	lb/a	99	a	99	a	98	a	99	a
6	Gallery Oust Extra	1 4	lb/a oz wt/a	100	a	100	a	100	a	100	a
7	Milestone VM	7	fl oz/a	66	b	28	b	23	b	25	b
8	Milestone VM Oust Extra	5 4	fl oz/a oz wt/a	99	a	100	a	99	a	99	a
9	indaziflam	5	oz/a	99	a	100	a	99	a	99	a
10	indaziflam Oust Extra	5 4	oz/a oz wt/a	100	a	100	a	100	a	100	a
11	Prodiamine Roundup Pro Concentrate	2.3 25	lb/a fl oz/a	100	a	98	a	97	a	99	a
12	Pendulum Aquacap Roundup Pro Concentrate	4.8 25	qt/a fl oz/a	100	a	100	a	100	a	99	a
13	MAT28 (Plainview 10 oz.) Oust XP Telar XP	6.24 2.5 1.25	oz wt/a oz wt/a oz wt/a	100	a	100	a	100	a	98	a
14	MAT28 (Streamline 8 oz.) Escort XP Oust XP	6.3 1.68 3	oz wt/a oz wt/a oz wt/a	100	a	100	a	100	a	99	a
15	MAT28 (Perspective 8 oz.) Telar XP Oust XP	6.3 2.1 3	oz wt/a oz wt/a oz wt/a	100	a	100	a	100	a	99	a
LSD[2] (P=.10)				14.1		18.4		15.8		16.4	
Standard Deviation				10.1		13.2		11.3		11.8	
CV				10.42		13.94		12.1		12.6	
Replicate F				0.907		0.96		0.629		0.73	
Replicate Prob(F)				0.4162		0.396		0.5412		0.4914	
Treatment F				2.325		6.284		9.626		8.442	
Treatment Prob(F)				0.0325		0.0001		0.0001		0.0001	

[1] DAA = days after application. [2]LSD = least significant difference test. Means sharing a common letter do not significantly differ at p = 0.10.NS = no significant differences present at p=0.10. Untreated checks were not included in the statistical analysis but their performance means are shown for comparative purposes.

Table 4. Comparison of long-term residual herbicide combinations for preemergence control of marestail in Study 4-H-11-12.

Pest Name				% Marestail Control							
Rating Date				5/7/2012		6/11/2012		7/2/2012		9/7/2012	
Trt-Eval Interval				63 DAA[1]		98 DAA		119 DAA		186 DAA	
Trt No.	Treatment Name	Rate	Rate Unit								
1	Untreated Check			0		0		0		5	
2	Oust Extra	5.13	oz wt/a	100	a	100	a	100	a	100	
3	Diuron	8	lb/a	100	a	100	a	100	a	100	
4	Diuron Oust Extra	5 4	lb/a oz wt/a	100	a	100	a	100	a	100	
5	Gallery	1.33	lb/a	67	a	67	ab	95	a	93	
6	Gallery Oust Extra	1 4	lb/a oz wt/a	100	a	100	a	100	a	100	
7	Milestone VM	7	fl oz/a	100	a	100	a	17	b	100	
8	Milestone VM Oust Extra	5 4	fl oz/a oz wt/a	100	a	99	a	100	a	100	
9	indaziflam	5	oz/a	0	b	27	b	97	a	77	
10	indaziflam Oust Extra	5 4	oz/a oz wt/a	100	a	100	a	100	a	100	
11	Prodiamine Roundup Pro Concentrate	2.3 25	lb/a fl oz/a	67	a	66	ab	99	a	83	
12	Pendulum Aquacap Roundup Pro Concentrate	4.8 25	qt/a fl oz/a	66	a	67	ab	100	a	73	
13	MAT28 (Plainview 10 oz.) Oust XP Telar XP	6.24 2.5 1.25	oz wt/a oz wt/a oz wt/a	100	a	100	a	100	a	100	
14	MAT28 (Streamline 8 oz.) Escort XP Oust XP	6.3 1.68 3	oz wt/a oz wt/a oz wt/a	100	a	100	a	100	a	100	
15	MAT28 (Perspective 8 oz.) Telar XP Oust XP	6.3 2.1 3	oz wt/a oz wt/a oz wt/a	100	a	100	a	100	a	100	
LSD[2] (P=.10)				38.6		42.2		11.5		NS	
Standard Deviation				27.7		30.3		8.2		17.5	
CV				32.31		34.58		8.84		18.45	
Replicate F				0		0.175		0.429		0.154	
Replicate Prob(F)				1		0.8404		0.6554		0.8577	
Treatment F				3.157		1.657		21.596		0.908	
Treatment Prob(F)				0.0061		0.1324		0.0001		0.5571	

[1]DAA = days after application. LSD = least significant difference test. Means sharing a common letter do not significantly differ at p = 0.10.NS = no significant differences present at p=0.10. Untreated checks were not included in the statistical analysis but their performance means are shown for comparative purposes.

Table 5. Comparison of long-term residual herbicide combinations for preemergence control of carpetweed in Study 4-H-11-12.

Pest Name				% Carpetweed Control							
Rating Date				5/7/2012		6/11/2012		7/2/2012		9/7/2012	
Trt-Eval Interval				63 DAA[1]		98 DAA		119 DAA		186 DAA	
Trt No.	Treatment Name	Rate	Rate Unit								
1	Untreated Check			0		0		0		0	
2	Oust Extra	5.13	oz wt/a	100	a	100	a	100		97	ab
3	Diuron	8	lb/a	100	a	100	a	100		100	a
4	Diuron Oust Extra	5 4	lb/a oz wt/a	100	a	100	a	100		100	a
5	Gallery	1.33	lb/a	100	a	98	a	65		89	b
6	Gallery Oust Extra	1 4	lb/a oz wt/a	100	a	100	a	100		99	a
7	Milestone VM	7	fl oz/a	60	b	18	b	100		55	c
8	Milestone VM Oust Extra	5 4	fl oz/a oz wt/a	100	a	100	a	100		98	ab
9	indaziflam	5	oz/a	100	a	100	a	33		99	a
10	indaziflam Oust Extra	5 4	oz/a oz wt/a	100	a	100	a	100		100	a
11	Prodiamine Roundup Pro Concentrate	2.3 25	lb/a fl oz/a	100	a	98	a	65		98	ab
12	Pendulum Aquacap Roundup Pro Concentrate	4.8 25	qt/a fl oz/a	100	a	93	a	63		98	ab
13	MAT28 (Plainview 10 oz.) Oust XP Telar XP	6.24 2.5 1.25	oz wt/a oz wt/a oz wt/a	100	a	100	a	100		99	a
14	MAT28 (Streamline 8 oz.) Escort XP Oust XP	6.3 1.68 3	oz wt/a oz wt/a oz wt/a	100	a	100	a	100		99	a
15	MAT28 (Perspective 8 oz.) Telar XP Oust XP	6.3 2.1 3	oz wt/a oz wt/a oz wt/a	100	a	100	a	100		99	a
LSD[2] (P=.10)				19.6		12.2		NS		9.9	
Standard Deviation				14		8.7		31		7.1	
CV				14.46		9.36		35.39		7.47	
Replicate F				1		0.706		0.223		0.945	
Replicate Prob(F)				0.3816		0.5031		0.8013		0.4016	
Treatment F				1.768		18.48		1.462		8.392	
Treatment Prob(F)				0.1048		0.0001		0.1981		0.0001	

[1] DAA = days after application. LSD = least significant difference test. Means sharing a common letter do not significantly differ at p = 0.10.NS = no significant differences present at p=0.10. Untreated checks were not included in the statistical analysis but their performance means are shown for comparative purposes.

Table 6. Comparison of long-term residual herbicide combinations and end-of-season bareground levels in Study 4-H-11-12.

Pest Name				% Bareground	
Rating Date				11/8/2012	
Trt-Eval Interval				248 DAA[1]	
Trt No.	Treatment Name	Rate	Rate Unit		
1	Untreated Check			18	
2	Oust Extra	5.13	oz wt/a	61	c
3	Diuron	8	lb/a	99	a
4	Diuron Oust Extra	5 4	lb/a oz wt/a	99	a
5	Gallery	1.33	lb/a	53	c
6	Gallery Oust Extra	1 4	lb/a oz wt/a	97	a
7	Milestone VM	7	fl oz/a	37	d
8	Milestone VM Oust Extra	5 4	fl oz/a oz wt/a	89	ab
9	indaziflam	5	oz/a	95	a
10	indaziflam Oust Extra	5 4	oz/a oz wt/a	99	a
11	Prodiamine Roundup Pro Concentrate	2.3 25	lb/a fl oz/a	78	b
12	Pendulum Aquacap Roundup Pro Concentrate	4.8 25	qt/a fl oz/a	63	c
13	MAT28 (Plainview 10 oz.) Oust XP Telar XP	6.24 2.5 1.25	oz wt/a oz wt/a oz wt/a	89	ab
14	MAT28 (Streamline 8 oz.) Escort XP Oust XP	6.3 1.68 3	oz wt/a oz wt/a oz wt/a	94	a
15	MAT28 (Perspective 8 oz.) Telar XP Oust XP	6.3 2.1 3	oz wt/a oz wt/a oz wt/a	98	a
LSD[2] (P=.10)				12.2	
Standard Deviation				8.7	
CV				9.36	
Replicate F				0.706	
Replicate Prob(F)				0.5031	
Treatment F				18.48	
Treatment Prob(F)				0.0001	

[1] DAA = days after application. LSD = least significant difference test. Means sharing a common letter do not significantly differ at p = 0.10.NS = no significant differences present at p=0.10. Untreated checks were not included in the statistical analysis but their performance means are shown for comparative purposes.

3.0 EVALUATION OF SELECTED HERBICIDE COMBINATIONS FOR THEIR ABILITY TO PROVIDE LONG-TERM RESIDUAL WEED CONTROL UNDER CABLE BARRIERS (STUDY 4-H-12-12)

3.1 BACKGROUND

Over the past several years most ODOT field divisions have continued to install cable barrier systems on one or both sides of center medians. The composition of the cable barrier base varies from installation to installation. Generally the base material is either compressed small rock or asphalt millings. The footprint of the base varies significantly between installations. It can be as narrow as 3-4 feet or as wide 12-14 feet and even wider in transition areas. Regardless of the installation, one of the challenges in utilization of the cable barriers continues to be a need for long-term weed control within the footprint. The cable barrier presents a physical impediment to mowing and weed eating. We are continuing to screen herbicide combinations that may provide for long-term residual weed control in cable barrier systems. Interim recommendations have been developed for weed control in these areas while research proceeds.

Interim recommendations were made for ODOT to apply Prodiamine 65 WDG herbicide at a maximum labeled rate of 2.3 lb. product/A for pre-emergence weed control. Prodiamine 65 WDG is a preemergence herbicide that when applied at the recommended rates prior to weed emergence should provide for good to excellent control of many summer and winter annual weeds. Suitable activity is generally contingent upon receiving a minimum of 0.5 inches of rainfall at least 3 weeks prior to the germination of target weeds so that this pre-emergent herbicide can be moved into the soil. Also, based on the 2011 weed control results in study 4-H-7-11 (Preemergence Cable Barrier Residual Weed Control Study), interim 2012 recommendations were made for the use of Perspective at 8.0 ounces of product/A plus Oust XP at 3 ounces of product/A. Applications of this combination were to be made in late February to early March with the goal of providing the necessary residual annual weed control for the cable barrier footprint for the entire growing season. However, since this treatment has limited activity on perennial weed species it is necessary to address perennial weed problems within the cable barrier in early to mid summer with an additional herbicide treatment. The additional treatment could be glyphosate. OSU personnel can be consulted as to target species, rate, and treatment timing.

3.2 OBJECTIVES

The objective of this trial was to evaluate selected treatments from the 2011 trial (Study 4-H-7-11) for their ability to produce season-long residual annual weed control when applied to a cable barrier footprint. Treatments were selected based on their ability to produce and maintain complete, or near complete season-long annual weed control in last years study.

3.3 MATERIALS AND METHODS

This study was located underneath the cable barrier along I-35, beginning approximately 1.6 mile north of the junction of I-35 and US-77 north near Guthrie, Oklahoma. Plots size in this trial was 5 feet wide by 21 feet long. The length of each plot was the area amongst 3 cable barrier poles (21 feet) separated from adjacent treatments by an untreated area 10.5 feet (area between two poles) and approximately 5 feet in width (Table 7). Leaving an untreated area between each treated plot was intended to allow for documentation of any herbicide treatment migration out of their respective treated zones by way of surface water runoff. The soil type on the test site was native soil mixed with asphalt millings. Milling inclusion into the soil was 3 - 6 inches in depth from the surface. The surface of the cable barrier footprint had varying amounts of soil siltation. Much of the airspace amongst asphalt particles was filled with soil and organic debris. This siltation allowed for a site of weed infestation. As the main objective was to evaluate products for preemergence activity, all treatments included Roundup Pro Concentrate at 25 ounces product/A to control emerged winter weeds. Winter annual weeds present on March 3 (day of trial initiation) were annual ryegrass [*Lolium multiflora*], sheperdspurse [*Capsella bursa pastoris*], and hairy vetch [*Vicia villosa]*.

The research area was monitored during 2011 and 2012. We selected the trial area due to existing palmer amaranth [*Amaranthus palmeri]* and large crabgrass [*Digitaria sanguinalis*] being present in 2011. Populations appeared to have suitable number and uniformity of infestation ions and target weeds matured and set seed during late summer/fall of 2011.

The research area received good rainfall on March 8 (~0.7 inches) and March 11 (0.2 inches) which should have been more than adequate to activate all herbicides in this trial (11). It is worth noting that on March 19, 16 days after initial treatment, the area received a very heavy 1.78 inch rainfall event that produced lateral surface water movement across the research plots. This was evident from vegetation accumulating next to cable barrier posts within the experimental area. Under these conditions it is possible that some herbicide migration occurred. It is also important to note that no summer annual weed species had emerged at the time of treatment. Preemergence weed control evaluations were taken on the summer annual weeds, palmer amaranth and large crabgrass. Preemergence weed control data was collected monthly for each of these weed species through 8 months-after-treatment (MAT). Agricultural Research Manager Software (ARM) was used to conduct an Analysis of Variance (ANOVA) procedure on the data and when the treatment effect was found significant at the 90% certainty level (p=0.10) means were separated with Fishers Least Significant Difference (LSD) test.

3.4 RESULTS AND DISCUSSION

To aid in weed control evaluations and monitor potential lateral herbicide movement, non-treated paired check plots were located between each treated plot in this study.

The purpose of the paired checks was to try to ensure that adequate comparative checks were present. This should have provided for normal weed emergence and growth allowed meaningful comparison between adjacent non-treated and treated plots during evaluations. It became evident early in this trial (May) that weed emergence was

Table 7. Herbicide application specifics for experiment 4-H-12-12.

Application Factor	**Measurement**
Application Date:	March-3-2012
Time of Day:	8:25 a.m.
Plot Size:	21 feet x 5 feet (with 10.5 foot paired check)
Application Method:	Broadcast spray
Application Timing:	Postemergence
Application Placement:	Foliar
Air Temperature:	38 F
Relative Humidity:	50 %
Wind Velocity:	3 MPH
Wind Direction:	S
Dew Presence (Y/N):	No
Soil Temperature:	48 F
Soil Moisture:	good
Cloud Cover:	10 %
Appl. Equipment:	4-wheeler
Operating Pressure:	27 PSI
Nozzle Type:	Boomjet
Nozzle Size:	XP10R-VR
Nozzles/Row:	1
Boom Height:	24 inches
Ground Speed:	2.7 MPH
Carrier:	Water
Spray Volume:	30 gallons per acre
Mix Size:	1.8 liters
Propellant:	CO2

very low in both treated and untreated paired checks. This was expected in the treated plots but not in the non-treated paired checks. As this research site was on a slight slope there was potential that some lateral herbicide movement had occurred from the treated plots into adjacent non-treated paired checks. This would account for the lack of weed emergence in the non-treated paired checks. However, the weed emergence and response throughout the 600 foot long trial was very consistent. This type of response should not have been present for all herbicide treated areas as there were herbicide treatments which typically produce little to no lateral movement, such as prodiamine. The weed emergence was monitored closely and the final conclusion was that there was most likely very little lateral herbicide movement in this trial and that the low level of weed emergence in the untreated paired checks was simply due to a low population of palmer amaranth and large crabgrass in the cable barrier footprint (Table 8). With this scenario present throughout the late spring and summer, weed control evaluations were very difficult. Also late summer weed control data is not available because of the inadvertent July treatment of glyphosate that was sprayed over the top of this study by a private contractor. The following discussion was based on personal observations of vegetation responses in consideration of all variables that have been mentioned.

The Analysis of Variance Proceedure (ANOVA) only found statistical differences in palmer amaranth control (p=0.10) to be present at 61 DAT. At 61, 94, and 122 DAA (days-after-application) treatments of Gallery plus Oust Extra, indaziflam plus Oust Extra, and prodiamine were providing the numerically most consistent and highest level of palmer amaranth control (Table 8). These treatments were providing complete or near complete control of palmer amaranth through late summer. Treatments of diuron plus Oust Extra, Streamline plus Oust, and Perspective plus Oust, while producing good control of palmer amaranth in OSU study 4-H-11-12 were not maintaining acceptable levels of control in this particular study.

The Analysis of Variance Procedure (ANOVA) found no statistical differences in crabgrass control so our discussion will proceed based on numeric differences. All treatments were producing excellent control of large crabgrass through 61 and 94 DAA evaluations. However, by 122 DAA evaluations several treatments were beginning to show signs of breaking and allowing large crabgrass to reinfest the cable barrier footprint. At 122 DAA only the treatment of prodiamine was maintaining near complete control of large crabgrass with other treatments allowing for 3-9% large crabgrass ground cover. Within current ODOT cable barrier systems, if weeds such as large crabgrass or palmer amaranth escaped residual herbicide treatments and were producing 5-10% ground cover, it would probably result in the need for an additional herbicide treatment of glyphosate to maintain the desirable bareground.

Common bermudagrass was present in all plots prior to treatment. With the weed control provided by the herbicide treatments, the common bermudagrass increased over the course of the trial (Table 9). While in most cable barrier systems ODOT may consider common bermudagrass as a weed, there are some cable barriers with slopes and erosion potential where common bermudagrass would be a desirable plant in the cable barrier footprint. By design, the herbicide treatments that are currently under development by OSU as potential cable barrier weed control treatment have a high degree of selectivity on common bermudagrass. Common bermudagrass growing in or adjacent to cable barrier footprints should be tolerant of the treatment combinations under evaluation. Removal of competitive weeds from the bermudagrass should result in it continuing to spread into the cable barrier.

No statistical differences in common bermudagrass cover was found in this trial but numeric differences were present (Table 9). As expected common bermudagrass ground cover increased for all treatments following applications. Common bermudagrass ground cover increased during this trial in the range of 18 -37%. This type of response may be desirable if ODOT personnel are wanting to release common bermudagrass and protect against erosion. However, the herbicides selected by OSU in these studies have been selected considering the fact that these herbicides have a lower potential to move laterally and are considered to be “softer residual” herbicides. There are herbicides that include active ingredients such as bromacil and prometon that are considered to be “soil sterilants” but they were not tested in this trial. These types of herbicides can produce control of all vegetation types, including common bermudagrass and other hard-to-control perennials. Because of their persistent nature and lateral movement problems these materials would not be considered “soft residuals”. These products have been intentionally left out of the development process when looking for a long-term residual weed control treatment for ODOT cable barrier systems. To provide for control of common bermudagrass and other hard-to-control perennials, we recommend that ODOT provide a late winter to early spring treatment of a residual herbicide followed by an early to mid summer glyphosate treatment to control common bermudagrass.

3.5 CONCLUSIONS

We do not feel that the quantity of research trials conducted to this point in time on the cable barrier use site allows for extensive conclusions to be drawn. Due to the challenges presented by the over spray application of glyphosate by the private contractor, the effects of the drought and the resultant variable weed populations, the quality of research results fell well below what we expected. This being said, the tank mix treatment of indaziflam plus Oust Extra produced the best overall weed free cable barrier footprint followed closely by a tank mix of Gallery, Oust Extra and prodiamine. Common bermudagrass appeared tolerant of the evaluated treatments, rates of application, and timing of application.

3.6 RECOMMENDATIONS

We recommend the continued evaluation of herbicide treatments that have potential for long-term residual weed control in the cable barrier footprint. We will likely have to adjust the design, selection, set up, and maintenance of the experimental sites. Conducting research trials within an existing cable barrier is much more difficult than conducting traditional roadside weed control trials in clear zones and back slope areas. Better research techniques need to be developed that take into consideration the footprint barrier itself. Application techniques that prevent spray pattern shadowing by the cables and posts are needed as well as a possible rethinking of techniques to increase safety to the applicator on the ground treating the cable barrier research trial.

Table 8. Comparison of herbicide combinations for preemergence control of palmer amaranth and large crabgrass in Study 4-H-12-12.

Pest Name				% Palmer Amaranth Cover						% Large Crabgrass Cover					
Rating Date				5/3/2012		6/5/2012		7/3/2012		5/3/2012		6/5/2012		7/3/2012	
Trt-Eval Interval				61 DAA[1]		94 DAA		122 DAA		61 DAA		94 DAA		122 DAA	
Trt No.	Treatment Name	Rate	Rate Unit												
1	Diuron Oust Extra Roundup Pro Conc.	5 4 25	lb/a oz wt/a fl oz/a	1	a	5		6		2		1		6	
2	Gallery Oust Extra Roundup Pro Conc.	1 4 25	lb/a oz wt/a fl oz/a	1	a	1		2		0		1		9	
3	Milestone VM Oust Extra Roundup Pro Conc.	5 4 25	fl oz/a oz wt/a fl oz/a	1	a	3		5		1		6		8	
4	indaziflam Oust Extra Roundup Pro Conc.	5 4 25	oz/a oz wt/a fl oz/a	0	b	0		1		0		0		3	
5	Prodiamine Roundup Pro Conc.	2.3 25	lb/a fl oz/a	0	b	1		2		0		1		2	
6	MAT28 (Streamline 8 oz.) Escort XP Oust XP Roundup Pro Conc.	6.3 1.68 3 25	oz wt/a oz wt/a oz wt/a fl oz/a	1	a	3		4		2		1		6	
7	MAT28 (Perspective 8 oz.) Telar XP Oust XP Roundup Pro Conc.	6.3 2.1 3 25	oz wt/a oz wt/a oz wt/a fl oz/a	1	a	5		7		1		2		4	
LSD[2] (P=.10)				1		NS		NS		NS		NS		NS	
Standard Deviation				0.7		2.2		3.1		1.1		3		4.5	
CV				79.83		86.96		80.61		126.01		164.62		82	
Replicate F				3.966		0.6		0.724		0.857		1.551		1.132	
Replicate Prob(F)				0.0476		0.5645		0.5048		0.4488		0.2517		0.3546	
Treatment F				2.576		2.171		1.872		1.224		1.113		1.064	
Treatment Prob(F)				0.0769		0.1192		0.1673		0.3591		0.4101		0.4345	

[1] DAA = days after application. LSD = least significant difference test. Means sharing a common letter do not significantly differ at p = 0.10.NS = no significant differences present at p=0.10. Untreated checks were not included in the statistical analysis but their performance means are shown for comparative purposes.

Table 9. Comparison of herbicide combinations for release of common bermudagrass in Study 4-H-12-12.

Pest Name				% Common Bermudagrass Cover					
Rating Date				5/3/2012		6/5/2012		7/3/2012	
Trt-Eval Interval				61 DAA[1]		94 DAA		122 DAA	
Trt No.	Treatment Name	Rate	Rate Unit						
1	Diuron	5	lb/a	10		38		47	
	Oust Extra	4	oz wt/a						
	Roundup Pro Conc.	25	fl oz/a						
2	Gallery	1	lb/a	22		40		45	
	Oust Extra	4	oz wt/a						
	Roundup Pro Conc.	25	fl oz/a						
3	Milestone VM	5	fl oz/a	17		35		38	
	Oust Extra	4	oz wt/a						
	Roundup Pro Conc.	25	fl oz/a						
4	indaziflam	5	oz/a	20		44		55	
	Oust Extra	4	oz wt/a						
	Roundup Pro Conc.	25	fl oz/a						
5	Prodiamine	2.3	lb/a	37		45		55	
	Roundup Pro Conc.	25	fl oz/a						
6	MAT28 (Streamline 8 oz.)	6.3	oz wt/a	24		35		42	
	Escort XP	1.68	oz wt/a						
	Oust XP	3	oz wt/a						
	Roundup Pro Conc.	25	fl oz/a						
7	MAT28 (Perspective 8 oz.)	6.3	oz wt/a	26		53		57	
	Telar XP	2.1	oz wt/a						
	Oust XP	3	oz wt/a						
	Roundup Pro Conc.	25	fl oz/a						
LSD[2] (P=.10)				NS		NS		NS	
Standard Deviation				21.4		18.9		19.9	
CV				95.74		45.43		41.16	
Replicate F				1.974		0.388		0.274	
Replicate Prob(F)				0.1814		0.6863		0.7652	
Treatment F				0.459		0.353		0.4	
Treatment Prob(F)				0.8258		0.8945		0.8652	

[1] DAA = days after application. LSD = least significant difference test. Means sharing a common letter do not significantly differ at p = 0.10.NS = no significant differences present at p=0.10. Untreated checks were not included in the statistical analysis but their performance means are shown for comparative purposes.

4.0 EVALUATION OF SELECTED HERBICIDE COMBINATIONS FOR THEIR ABILITY TO PROVIDE LONG-TERM RESIDUAL WEED CONTROL UNDER CABLE BARRIERS (STUDY 4-H-13-12)

4.1 BACKGROUND

The OSU RVM program is currently developing long-term residual weed control recommendations for ODOT personnel to use under cable barriers. One of the more promising herbicides examined was Esplanade (12), active ingredient indaziflam, a product from Bayer Crop Science. Labeled in 2011, Esplande has shown potential in past OSU weed control studies to provide excellent residual annual weed control on species such as annual grass and to a lesser extent, several annual broadleaves. While Esplanade is highly unlikely to be a standalone herbicide for cable barrier weed control programs, it has great potential to be a critical component in tank mixtures targeted for cable barrier sites. Since it has limited activity on perennial weeds it would be considered a “soft residual” herbicide. The structure of this trial was to combine Esplanade with other herbicides that have better broadleaf weed control properties that can complement Esplanade.

4.2 OBJECTIVES

The objective of this research was to evaluate indaziflam tank mixtures for season-long control of annual grasses and broadleaf weeds within the cable barrier footprint.

4.3 MATERIALS AND METHODS

This study was located underneath the cable barrier along I-35, 2.4 mile north of the junction of I-35 and US-77 north near Guthrie, Oklahoma. Plot dimension were 21 by 5 feet. The length of each plot was that amongst 3 cable barrier poles (21 feet) separated from adjacent treatments by an untreated area that was 10.5 feet in length (distance between two poles) and approximately 5 feet in width (Table 10). Leaving an untreated area between each treated plot was for documentation of any herbicide treatment migration out of the treated zones by way of surface water runoff. The soil type on the test site was composed of asphalt millings, varying in depth from 3-6 inches. The surface of the cable barrier footprint had varying amounts of soil siltation that had filled most of the airspace within the millings. The purpose of the trial was to evaluate preemergence capabilities of selected herbicide combinations so all treatments contained the addition of Roundup Pro Concentrate at 25 ounces product/A to provide for control of all emerged winter weeds. At treatment time (March 3, 2012) winter annual weeds present were annual ryegrass [*Lolium multiflora*], sheperdspurse [*Capsella bursa pastoris*], and hairy vetch [*Vicia villosa*].

The research area was monitored during the 2011 and 2012 season and was selected on the basis of existing stands of palmer amaranth and large crabgrass within the cable barrier footprint as documented in late summer/fall of 2011.

The research area received good rainfall on March 8 (~0.7 inches) and March 11 (0.2 inches) which should have been more than adequate to activate all herbicides in this trial (11). It is worth noting that on March 19, 16 days after initial treatment, the area received a very heavy 1.78 inch rainfall event. There appeared to be very little lateral movement of herbicides in this trial as a result of this heavy rainfall event. It is important to note that no summer annual weed species had emerged at the time of treatment. Preemergence weed control evaluations were taken on the summer annual weeds, palmer amaranth (*Amaranthus palmeri*) and large crabgrass (*Digitaria sanguinalis*). Preemergence weed control data was collected monthly for each of these weed species through 8 months-after-treatment (MAT). Agricultural Research Manager Software (ARM) was used to conduct an Analysis of Variance (ANOVA) procedure on the data and when the treatment effect was found significant at the 90% certainty level (p=0.10) means were separated with Fishers Least Significant Difference (LSD) test.

Table 10. Herbicide application specifics for experiment 4-H-13-12.

Application Factor	**Measurement**
Application Date:	March-3-2012
Time of Day:	7:15 a.m.
Plot Size:	21 feet x 5 feet (with 10.5 foot paired check)
Application Method:	Broadcast spray
Application Timing:	Postemergence
Application Placement:	Foliar
Air Temperature:	34 F
Relative Humidity:	50 %
Wind Velocity:	1 MPH
Wind Direction:	S
Dew Presence (Y/N):	No
Soil Temperature:	48 F
Soil Moisture:	good
Cloud Cover:	10 %
Appl. Equipment:	4-wheeler
Operating Pressure:	27 PSI
Nozzle Type:	Boomjet
Nozzle Size:	XP10R-VR
Nozzles/Row:	1
Boom Height:	24 inches
Ground Speed:	2.7 MPH
Carrier:	Water
Spray Volume:	30 gallons per acre
Mix Size:	1.8 liters
Propellant:	CO_2

4.4 RESULTS AND DISCUSSION

To aid in weed control evaluations and monitor potential lateral herbicide movement, untreated paired check plots were located between each treated plot in this study. The purpose of inclusion of untreated paired checks was to provide for normal weed emergence and growth as well as to use in comparison to those adjacent treated plots during evaluations. It became evident in May that weed populations were low in the cable barrier footprint for both treated and untreated paired checks. This was somewhat expected in some treated plots but not in the untreated paired checks. The research site was on a relatively flat area; consequently the potential for lateral herbicide movement into adjacent untreated paired checks was minimal. Thus, the low level of weed emergence in the untreated paired checks was likely due to a low population of palmer amaranth in the cable barrier footprint (Table 11) despite scouting and declaring the site as a good test site in late summer/early fall 2011.

As the poor weed uniformity was present through early summer, weed control evaluations were very difficult. Also late summer weed control (150 and 180 DAA) data is not available because of the inadvertent July treatment of glyphosate that was sprayed over the top of this study by a private contractor. An attempt was also made to collect fall winter annual weed control (~240 DAA), however, at that time there were very few winter annual weeds present in the experimental area or in the roadsides adjacent to the site. This was likely due to persistant drought conditions. Decisions were made to conclude 2012 weed control observations in an attempt to produce final weed control conclusions and final reporting.

Weed control discussion is based on statistical differences found amongst herbicide treatments as well as simple numeric differences when statistical differences were not present. At 61 DAA (May 3) no statistical differences amongst treatments were present with respect to palmer amaranth control as there was very little palmer amaranth that had emerged in the untreated check treatment or untreated paired checks. This being said, no palmer amaranth emergence was found in any of the treated plots, including Roundup Pro Concentrate alone. The Analysis of Variance Proceedure (ANOVA) found statistical differences present at 94 and 122 DAA. At 94 DAA (June 5) palmer amaranth emergence had occurred in all untreated plots and untreated paired checks but was at very low levels, 1 - 4% ground cover. At 94 DAA all treatments including Esplanade were maintaining complete control of palmer amaranth while standard treatments of diuron plus Oust Extra, Oust Extra plus prodiamine, and Perspective plus Oust XP were allowing palmer amaranth to escape the treatment. These treatments were allowing an average of 1 - 2 palmer amaranth plants per plot. While this is a low level of emergence it was fairly consistent throughout the study area. At the final 122 DAA evaluations, and after hot, dry summer conditions had set in, palmer amaranth control levels remained very similar to those at the 94 DAA evaluations. All treatments including the Esplanade product were maintaining complete or near complete control of palmer amaranth. At this time palmer amaranth continued to slowly emerge and develop in the untreated check, untreated paired checks, and the Roundup Pro Concentrate alone treatment.

While large crabgrass emerged and developed later that expected there was a good population within the study area. The ANOVA found statistical differences at p=0.10 level at 61, 94 and 122 DAA. At 61 DAA large crabgrass emergence had begun but was well behind what would normally occur in early May. This was due to the cool, late spring conditions. By 94 DAA all treatments that included the Esplanade product were producing complete control of large crabgrass, while standard treatments of diruon plus Oust Extra and Perspective plus Oust XP were producing fair to poor control of large crabgrass (Table 11). The standard treatment of Oust Extra plus prodiamine was producing near complete control of large crabgrass. The standard treatment of Perspective plus Oust XP was providing no large crabgrass control. By the date of the final evaluations at 122 DAA, and prior to the firing of large crabgrass from summer drought conditions, all treatments including the Esplanade product were maintaining complete to near complete control of large crabgrass. The standard treatments were maintaining similar levels of large crabgrass control at 122 DAA as they were at 94 DAA. There did not appear to be new emergence of large crabgrass in the standard treatments. However, the crabgrass that had escaped the treatment continued to grow and development within the treated plot.

While common bermudagrass was not a targeted weed in this trial it was present in all plots at very low levels (Table 12). Common bermudagrass showed a high level of tolerance to all herbicide treatment combinations and herbicide rates. Most if not all treatments in this study would be considered common bermudagrass release treatments. This type of response may be desirable if ODOT personnel wish to control weeds but release common bermudagrass and protect against erosion.

4.5 CONCLUSIONS

Due to the many challenges and obstacles found during the conduct of this study the amount and quality of results fell well below what was expected. The treatments that included indaziflam as a tank mix partner produced consistently higher levels of control of both palmer amaranth and large crabgrass as compared to all standard treatments that were included. Because of the low weed populations in this study it is difficult to further separate possible treatment affects. The Esplanade product, with its length of residual control, appears to be a good candidate for a long-term residual weed control of annual but not perennial weeds.

4.6 RECOMMENDATIONS

The number of investigation on the cable barrier footprint is not extensive at this point in time. As such we cannot make final recommendations with great certainty. We recommend the continued evaluation of herbicides that appear to have longer-term residual preemergence control of weeds in the cable barrier footprint, especially those that include Esplanade as a tank mix partner.

Table 11. Comparison of herbicide combinations for preemergence control of palmer amaranth and large crabgrass in Study 4-H-13-12.

Pest Name				% Palmer Amaranth Cover						% Large Crabgrass Cover					
Rating Date				5/3/2012		6/5/2012		7/3/2012		5/3/2012		6/5/2012		7/3/2012	
Trt-Eval Interval				61 DAA		94 DAA		122 DAA		61 DAA		94 DAA		122 DAA	
Trt No.	Treatment Name	Rate	Rate Unit												
1	Roundup Pro Conc.	51.2	fl oz/a	0		4	a	7	a	2	b	9	b	16	a
2	Esplanade Roundup Pro Conc.	5 51.2	fl oz/a fl oz/a	0		0	b	0	b	0	c	0	c	0	b
3	Esplanade Oust Extra Roundup Pro Conc.	5 4 51.2	fl oz/a oz/a fl oz/a	0		0	b	0	b	0	c	0	c	2	b
4	Esplanade Milestone VM Escort Roundup Pro Conc.	3.5 7 1 51.2	fl oz/a fl oz/a oz/a fl oz/a	0		0	b	1	b	0	c	0	c	1	b
5	Esplanade Milestone VM Escort Roundup Pro Conc.	5 7 1 51.2	fl oz/a fl oz/a oz/a fl oz/a	0		0	b	0	b	0	c	0	c	0	b
6	Esplanade Streamline Roundup Pro Conc.	5 8 51.2	fl oz/a oz/a fl oz/a	0		0	b	0	b	0	c	0	c	0	b
7	Diuron Oust Extra Roundup Pro Conc.	5 4 51.2	lb/a oz/a fl oz/a	0		1	b	2	b	0	c	4	c	6	b
8	Oust Extra Prodiamine Roundup Pro Conc.	4 2.3 51.2	oz/a lb/a fl oz/a	0		1	b	2	b	0	c	1	c	3	b
9	Perspective Oust XP Roundup Pro Conc.	8 3 25.6	oz/a oz/a fl oz/a	0		1	b	3	b	2	a	14	a	24	a
10	Untreated Check			1		1		5		2		4		15	
LSD[2] (P=.10)				NS		1.8		3.5		0.7		4.7		8.9	
Standard Deviation				0.3		1.3		2.5		0.5		3.3		6.3	
CV				259.81		148.15		151.81		96.88		99.12		107.26	
Replicate F				4		1		0.769		1.191		3.084		3.625	
Replicate Prob(F)				0.039		0.3897		0.4801		0.3293		0.0736		0.0503	
Treatment F				1		3.041		2.797		10.766		7.528		5.601	
Treatment Prob(F)				0.4726		0.0278		0.0381		0.0001		0.0003		0.0017	

[1] DAA = days after application. [2]LSD = least significant difference test. Means sharing a common letter do not significantly differ at p = 0.10. NS = no significant differences present at p=0.10. Untreated checks were not included in the statistical analysis but their performance means are shown for comparative purposes.

Table 12. Comparison of herbicide combinations for release of common bermudagrass in Study 4-H-13-12.

Pest Name				% Common Bermudagrass Cover		
Rating Date				5/3/2012	6/5/2012	7/3/2012
Trt-Eval Interval				61 DAA	94 DAA	122 DAA
Trt No.	Treatment Name	Rate	Rate Unit			
1	Roundup Pro Conc.	51.2	fl oz/a	0	1	1
2	Esplanade	5	fl oz/a	1	1	2
	Roundup Pro Conc.	51.2	fl oz/a			
3	Esplanade	5	fl oz/a	1	1	1
	Oust Extra	4	oz/a			
	Roundup Pro Conc.	51.2	fl oz/a			
4	Esplanade	3.5	fl oz/a	1	2	3
	Milestone VM	7	fl oz/a			
	Escort	1	oz/a			
	Roundup Pro Conc.	51.2	fl oz/a			
5	Esplanade	5	fl oz/a	2	3	5
	Milestone VM	7	fl oz/a			
	Escort	1	oz/a			
	Roundup Pro Conc.	51.2	fl oz/a			
6	Esplanade	5	fl oz/a	3	4	6
	Streamline	8	oz/a			
	Roundup Pro Conc.	51.2	fl oz/a			
7	Diuron	5	lb/a	1	3	4
	Oust Extra	4	oz/a			
	Roundup Pro Conc.	51.2	fl oz/a			
8	Oust Extra	4	oz/a	0	0	1
	Prodiamine	2.3	lb/a			
	Roundup Pro Conc.	51.2	fl oz/a			
9	Perspective	8	oz/a	1	0	0
	Oust XP	3	oz/a			
	Roundup Pro Conc.	25.6	fl oz/a			
10	Untreated Check			0	1	1
LSD[2] (P=.10)				NS	NS	NS
Standard Deviation				2.2	3	4.6
CV				191.66	181.52	178.25
Replicate F				0.467	0.959	0.834
Replicate Prob(F)				0.6354	0.4042	0.4523
Treatment F				0.501	0.601	0.581
Treatment Prob(F)				0.8382	0.764	0.7795

[1] DAA = days after application. [2]LSD = least significant difference test. Means sharing a common letter do not significantly differ at p = 0.10.NS = no significant differences present at p=0.10. Untreated checks were not included in the statistical analysis but their performance means are shown for comparative purposes.

5.0 EVALUATION OF POSTEMERGENCE HERBICIDE COMBINATIONTREATMENTS FOR CONTROL OF SUMMER ANNUAL BROADLEAF AND GRASSY WEEDS (STUDY 4-H-14-12)

5.1 BACKGROUND

This trial served as a screening of several herbicide active ingredients under investigation by Bayer Crop Sciences. The active ingredients foramsulfuron (FSN), iodosulfuron-methyl-sodium (IMS), and thiencarbazone-methyl (TCM) are currently labeled for use on several agricultural crops and turf but are not currently labeled for non-crop roadside use. During the past few years Bayer Crop Sciences has shown a great deal of interest in developing and registering new herbicides for non-crop uses. This screening was conducted in an attempt to produce useful postemergence roadside weed control data on these new active ingredient combinations. We targeted one of the toughest summer annual weed species, palmer amaranth, along with prostrate spurge and large crabgrass.

5.2 OBJECTIVES

The objectives of this trial were i) to evaluate 17 herbicide treatments for their effectiveness in providing postemergence control of palmer amaranth, prostrate spurge, and large crabgrass, and ii) to assess the phytotoxic effect of these herbicide treatments on common bermudagrass (*Cynodon dactylon*).

5.3 MATERIALS AND METHODS

Treatments were applied on May 8 2012 to actively growing common bermudagrass. Weeds present were palmer amaranth (*Amaranth palmeri*) [0.5 - 4 inches high], prostrate spurge (*Chamaesyce humistrata*) [1 - 3 inch high rosettes], and large crabgrass (*Digitaria sanguinalis*) [0.4 - 4 inches in height] (Table 13). At treatment time common bermudagrass was 2 - 4 inches in height and actively growing. Percent control of palmer amaranth, large crabgrass, prostrate spurge control and common bermudagrass injury were visually evaluated at 14, 31, 62, 92, and 121 days-after-application (DAA). Agricultural Research Manager Software (ARM) was used to conduct an Analysis of Variance (ANOVA) procedure on the data and when the treatment effect was found significant at the 90% certainty level (p=0.10) means were separated with Fishers Least Significant Difference (LSD) test.

Table 13. Herbicide application specifics for experiment 4-H-14-12.

Application Factor	Measurement
Application Date:	May-8-2012
Time of Day:	7:15 a.m.
Application Method:	Broadcast spray
Application Timing:	Postemergence
Application Placement:	Foliar
Air Temperature:	58 F
Relative Humidity:	69 %
Wind Velocity:	3 MPH
Wind Direction:	SE
Dew Presence (Y/N):	No
Soil Temperature:	67 F
Soil Moisture:	dry
Cloud Cover:	60 %
Appl. Equipment:	Bicycle sprayer, green
Operating Pressure:	25 PSI
Nozzle Type:	XR Tee jet
Nozzle Size:	XR 8004VS
Nozzle Spacing, Unit:	20 inches
Nozzles/Row:	3
Boom Height:	18 inches
Ground Speed:	2.5 MPH
Carrier:	Water
Spray Volume:	30 gallons per acre
Mix Size:	1.8 liters
Propellant:	CO2

5.4 RESULTS AND DISCUSSION

Due to the mild 2012 Oklahoma winter and subsequent early spring, treatments were applied 3 - 4 weeks earlier than originally planned. Treatments were applied on May 8 2012 at which time palmer amaranth was 0.5 to 4 inches in height (~30% flowering), large crabgrass was 0.5 to 4 inches in height (well tillered), and prostrate spurge had 1-3 inch rosettes. Common bermudagrass was 100% green and actively growing at treatment time. During the four-month-duration of this study the soil moisture and temperature conditions were at extremes. During May through mid June (0, 14, and 31 DAA evaluations) surface soil moisture conditions at this site were good and air temperatures were moderate. These climatic conditions produced good growing conditions for existing vegetation and produced optimal conditions for herbicide uptake and translocation. Starting in late June through July (62 DAA evaluations) and into early August (92 DAA evaluations) moisture conditions and air temperatures were extreme. During this period the study site received less than 0.75 inches of rainfall as well as experienced extremely hot conditions (35 days at 100 F or above). In order to maintain weed growth and development irrigation was supplied to the study site on July 19 (~0.75 inches of water) and July 29 (~0.5 inches of water). The irrigation helped maintain growth of palmer amaranth but not large crabgrass or prostrate spurge during these severe conditions. During that time large crabgrass and prostrate spurge control data was taken but due to plant mortality from the extreme conditions the data was determined to be of little value. Leaf firing from drought also occurred during that time on Common bermudagrass but the grass quickly recovered in late August when some rainfall occurred and temperatures moderated.

At 14 DAA (days-after-application) only the standard treatments of Escalade 2 and Triclopyr 3A were producing acceptable (meaning %80 or greater) control of palmer amaranth (Table 14). All other treatments were producing varying amounts of palmer amaranth control which ranged from moderate growth suppression to low levels of necrosis. At 31 DAA evaluations several treatments were producing good to excellent levels of palmer amaranth control. Treatments of Escalade 2, Triclopyr 3A, and the three-way experimental product combined with Milestone VM were all producing greater than 90% control of palmer amaranth. At that time all of the standard treatments, excluding Plateau and Escort, along with the two-way experimental product plus Milestone VM were producing good (80% or greater) control of palmer amaranth. All of the two and three way experimental treatments were producing low levels of palmer amaranth growth suppression with little to no yellowing and necrosis of the palmer amaranth plants.

At 62 DAA all of the standard treatments, excluding Plateau, were producing and maintaining good to excellent control of palmer amaranth. While increased control of palmer amaranth occurred when treated with the two and three-way experimental treatments, the level of control being offered was below acceptable levels for most of these treatments. The two-way experimental treatment with Milestone VM was the exception as it maintained excellent levels of palmer control. At 62 DAA palmer amaranth control from other two and three-way experimental treatments ranged from 45-83.

At 92 and 121 DAA we found good to excellent palmer amaranth control was provided by most of the standard treatments, excluding Plateau and Escort. At that time palmer amaranth control from all two and three-way experimental treatments continued to decline and the levels of control being provided were less than those produced by most standard treatments. There did not appear to be a clear “rate response” of palmer amaranth to either the two or three-way experimental treatments.

At 14 DAA only the standard treatment of Plateau was producing significant control of large crabgrass; all other treatments were producing low levels of growth suppression and chlorosis (Table 15). With respect to the two and three-way experimental treatments, the three-way experimental treatments were producing higher levels of large crabgrass suppression when compared to the two-way experimental treatments. As with palmer amaranth control, no significant rate response was evident on the large crabgrass. By 31 DAA large crabgrass control had decreased for all treatments with the exception of Plateau. Plateau is the only treatment in this study that produced and maintained an acceptable level of large crabgrass control. Large crabgrass control ratings were taken in mid to late summer. Due to the extreme drought conditions and firing of large crabgrass plants the data was of little value.

At 14 DAA the standard treatments of Escalade 2, Triclopyr 3A, and Perspective plus Oust Extra were producing good to excellent control of prostrate spurge (Table 15). All other treatments were producing low levels of growth suppression with varying levels of chlorosis. By 31 DAA the standard treatments of Escalade 2 and Perspective plus Oust Extra were producing and maintaining excellent prostrate spurge control while control had decreased for all other treatments. Prostrate spurge control ratings were taken in mid to late summer but due to the extreme drought conditions and firing of the spurge plants the data was of little value.

At 14 DAA common bermudagrass showed very little response to all of the herbicide treatments in this study (Table 16). At that time only a slight growth suppression was present. By 31 DAA only the treatment of Plateau was producing any significant injury to common bermudagrass. The injury was in the form of complete growth suppression and moderate phytotoxicity (20%) that would be acceptable for roadsides. All other treatments were producing and maintaining very low levels of common bermudagrass growth suppression with no phytotoxicity. By 62 DAA the hot and dry conditions were beginning to have an effect on the common bermudagrass as evidenced by the necrosis in the untreated checks. At 62 DAA common bermudagrass injury had increased for all treatments with several treatments now producing unacceptable levels of injury. At that time we do believe that while the extreme weather may have predisposed the common bermudagrass to higher levels of herbicide injury, most injury was due to the extreme conditions and not the herbicides. The only exception was that the treatment of Plateau produced and maintained an unacceptable level of injury due to the high treatment rate chosen. By 92 DAA common bermudagrass had recovered and injury was not evident from any of the treatments.

5.5 CONCLUSIONS

The climatic conditions throughout the duration of this study were less than desirable. However at the time of initial treatment the weather conditions present were favorable for suitable herbicide uptake and translocation. Approximately 6 - 8 weeks after treatments were applied the severe drought and temperature conditions began impacting weed control levels. However, prior to these conditions several good weed control observations were made. With regards to the new 2-way (IMS+TCM) and 3-way (FSN+IMS+TCM) herbicide combinations from Bayer, these new products did not show the ability to provide for successful, consistent control of either palmer amaranth, large crabgrass, or prostrate spurge. Several of the standard treatments were able to provide for good to excellent control of these weeds, but most of the standard treatments include hormone herbicides that would limit their safe use along all highways with adjacent hormone-sensitive crops. While the Escalade 2 herbicide product (a mixture of

2,4-D, fluroxypyr, and dicamba) provided near complete control of all broadleaf weeds present, it contains two volatile herbicide components, those being fluroxypyr and dicamba. The standard treatment of Perspective herbicide (aminocyclopyrachlor and chlorsulfuron) plus Oust Extra (sulfometuron methyl and metsulfuron methyl) herbicide provided for good to excellent control of palmer amaranth and prostrate spurge control and the two herbicides (with a total of four components) of this treatment are already included in the 2012 current OSU recommended treatments to control this particular weed spectrum. All treatments produced very little injury to common bermudagrass, except for the treatment of Plateau which was applied at an excessive rate.

5.6 RECOMMENDATIONS

The experimental 2-way and 3-way herbicide combinations provided by Bayer Crop Science for investigation in this trial did not provide very good levels of weed control relative to a standard treatment consisting of Perspective and Oust Extra which is already recommended. However we recommend the continued investigation of these offerings from Bayer if the manufacturer continues to proceed towards a roadside label. These herbicides could possibly benefit from being tank mixed with additional materials in the future that were not screened in this particular trial. Communications will continue with Bayer developmental scientists to monitor their intentions for possible labeling of these and other roadside herbicides.

Table 14. Comparison of combinations for postemergence control of palmer amaranth. Study 4-H-14-12.

Pest Name				% Palmer Amaranth Control									
Rating Date				5/22/2012	6/8/2012		7/9/2012		8/8/2012		9/6/2012		
Trt-Eval Interval				14 DAA[1]	31 DAA		62 DAA		92 DAA		121 DAA		
Trt No.	Treatment Name	Rate	Rate Unit										
1	Untreated Check			17	13		60		28		17		
2	FSN+IMS+TCM WG non-ionic surfactant	3 0.25	oz wt/a % v/v	45	43	b	83	ab	77	abc	80	a	
3	FSN+IMS+TCM WG non-ionic surfactant	4.5 0.25	oz wt/a % v/v	55	35	bc	66	bc	60	c	51	bc	
4	FSN+IMS+TCM WG non-ionic surfactant	6 0.25	oz wt/a % v/v	37	13	c	45	c	23	d	40	c	
5	FSN+IMS+TCM WG Milestone non-ionic surfactant	4.5 5 0.25	oz wt/a fl oz/a % v/v	60	93	a	76	ab	61	bc	73	ab	
6	IMS+TCM non-ionic surfactant	0.7 0.25	oz wt/a % v/v	43	13	c	48	c	20	d	32	cd	
7	IMS+TCM non-ionic surfactant	1 0.25	oz wt/a % v/v	63	28	bc	50	c	30	d	40	c	
8	IMS+TCM non-ionic surfactant	1.4 0.25	oz wt/a % v/v	50	32	bc	60	bc	17	d	39	c	
9	IMS+TCM Milestone non-ionic surfactant	1 5 0.25	oz wt/a fl oz/a % v/v	67	86	a	91	a	75	abc	86	a	
10	Celsius non-ionic surfactant	4.9 0.25	oz wt/a % v/v	68	84	a	92	a	83	abc	89	a	
11	Celsius non-ionic surfactant	7.4 0.25	oz wt/a % v/v	62	80	a	92	a	88	ab	88	a	
12	Plateau non-ionic surfactant	6 0.25	fl oz/a % v/v	38	35	bc	18	d	3	d	7	d	
13	Milestone non-ionic surfactant	7 0.25	fl oz/a % v/v	68	80	a	96	a	91	a	95	a	
14	Escort XP non-ionic surfactant	1 0.25	oz wt/a % v/v	53	32	bc	83	ab	73	abc	75	ab	
15	Escalade 2 non-ionic surfactant	48 0.25	fl oz/a % v/v	93	95	a	99	a	98	a	100	a	
16	Triclopyr 3A non-ionic surfactant	48 0.25	fl oz/a % v/v	85	93	a	98	a	96	a	99	a	
17	Perspective Oust Extra non-ionic surfactant	4.75 1.5 0.25	oz wt/a oz wt/a % v/v	67	83	a	96	a	92	a	92	a	
LSD[2] (P=.10)				NS	22.5		24.3		28.3		28.4		
Standard Deviation				21.8	16.2		17.5		20.4		20.5		
CV				36.48	28.02		23.47		33.12		30.24		
Replicate F				1.169	2.521		3.864		5.397		5.448		
Replicate Prob(F)				0.3244	0.0973		0.0321		0.01		0.0096		
Treatment F				1.559	10.949		5.667		7.482		5.894		
Treatment Prob(F)				0.1462	0.0001		0.0001		0.0001		0.0001		

[1]DAA = days after application. [2]LSD = least significant difference test. Means sharing a common letter do not significantly differ at p = 0.10.NS = no significant differences present at p=0.10. Checks not analyzed.

Table 15. Comparison of combinations for postemergence control of large crabgrass and prostrate spurge in Study 4-H-14-12.

Pest Name				% Large Crabgrass Control				% Prostrate Spurge Control			
Rating Date				5/22/2012		6/8/2012		5/22/2012		6/8/2012	
Trt-Eval Interval				14 DAA[1]		31 DAA		14 DAA		31 DAA	
Trt No.	Treatment Name	Rate	Rate Unit								
1	Untreated Check			3		8		22		0	
2	FSN+IMS+TCM WG non-ionic surfactant	3 0.25	oz wt/a % v/v	45	abc	8	cd	38	bc	0	c
3	FSN+IMS+TCM WG non-ionic surfactant	4.5 0.25	oz wt/a % v/v	38	bcd	28	c	32	bc	0	c
4	FSN+IMS+TCM WG non-ionic surfactant	6 0.25	oz wt/a % v/v	47	abc	22	cd	18	c	0	c
5	FSN+IMS+TCM WG Milestone	4.5 5	oz wt/a fl oz/a	20	cde	18	cd	53	b	5	c
	non-ionic surfactant	0.25	% v/v								
6	IMS+TCM non-ionic surfactant	0.7 0.25	oz wt/a % v/v	27	b-e	8	cd	32	bc	0	c
7	IMS+TCM non-ionic surfactant	1 0.25	oz wt/a % v/v	15	de	15	cd	37	bc	0	c
8	IMS+TCM non-ionic surfactant	1.4 0.25	oz wt/a % v/v	37	bcd	13	cd	40	bc	0	c
9	IMS+TCM Milestone non-ionic surfactant	1 5 0.25	oz wt/a fl oz/a % v/v	7	e	3	d	33	bc	23	c
10	Celsius non-ionic surfactant	4.9 0.25	oz wt/a % v/v	12	de	18	cd	33	bc	13	c
11	Celsius non-ionic surfactant	7.4 0.25	oz wt/a % v/v	55	ab	8	cd	53	b	17	c
12	Plateau non-ionic surfactant	6 0.25	fl oz/a % v/v	73	a	83	a	38	bc	3	c
13	Milestone non-ionic surfactant	7 0.25	fl oz/a % v/v	35	b-e	8	cd	48	b	48	b
14	Escort XP non-ionic surfactant	1 0.25	oz wt/a % v/v	37	bcd	22	cd	37	bc	13	c
15	Escalade 2 non-ionic surfactant	48 0.25	fl oz/a % v/v	44	abc	28	c	90	a	95	a
16	Triclopyr 3A non-ionic surfactant	48 0.25	fl oz/a % v/v	38	bcd	13	cd	83	a	57	b
17	Perspective Oust Extra non-ionic surfactant	4.75 1.5 0.25	oz wt/a oz wt/a % v/v	18	cde	58	b	80	a	96	a
LSD[2] (P=.10)				29.3		24.2		26.2		24.4	
Standard Deviation				21.1		17.4		18.9		17.6	
CV				61.77		78.36		40.62		76	
Replicate F				7.808		0.916		1.994		1.298	
Replicate Prob(F)				0.0019		0.4112		0.1538		0.2881	
Treatment F				2.027		4.212		3.55		10.561	
Treatment Prob(F)				0.0486		0.0004		0.0015		0.0001	

[1]DAA = days after application. [2]LSD = least significant difference test. Means sharing a common letter do not significantly differ at p = 0.10.NS = no significant differences present at p=0.10. Checks not analyzed.

Table 16. Comparison of combinations for common bermudagrass injury in Study 4-H-14-12.

Crop Name				% Common Bermudagrass Injury							
Rating Date				5/22/2012		6/8/2012		7/9/2012		8/8/2012	
Trt-Eval Interval				14 DAA[1]		31 DAA		62 DAA		92 DAA	
Trt No.	Treatment Name	Rate	Rate Unit								
1	Untreated Check			0		0		8		0	
2	FSN+IMS+TCM WG non-ionic surfactant	3 0.25	oz wt/a % v/v	4	bcd	4	c	12	de	0	
3	FSN+IMS+TCM WG non-ionic surfactant	4.5 0.25	oz wt/a % v/v	3	cd	3	c	9	e	0	
4	FSN+IMS+TCM WG non-ionic surfactant	6 0.25	oz wt/a % v/v	3	cd	2	c	15	cde	0	
5	FSN+IMS+TCM WG Milestone non-ionic surfactant	4.5 5 0.25	oz wt/a fl oz/a % v/v	3	cd	2	c	15	cde	0	
6	IMS+TCM non-ionic surfactant	0.7 0.25	oz wt/a % v/v	3	cd	2	c	38	ab	0	
7	IMS+TCM non-ionic surfactant	1 0.25	oz wt/a % v/v	4	bcd	3	c	33	abc	0	
8	IMS+TCM non-ionic surfactant	1.4 0.25	oz wt/a % v/v	3	cd	3	c	23	b-e	0	
9	IMS+TCM Milestone non-ionic surfactant	1 5 0.25	oz wt/a fl oz/a % v/v	4	bcd	3	c	20	b-e	0	
10	Celsius non-ionic surfactant	4.9 0.25	oz wt/a % v/v	3	d	1	c	30	a-d	0	
11	Celsius non-ionic surfactant	7.4 0.25	oz wt/a % v/v	5	bc	2	c	22	b-e	0	
12	Plateau non-ionic surfactant	6 0.25	fl oz/a % v/v	8	a	20	a	48	a	0	
13	Milestone non-ionic surfactant	7 0.25	fl oz/a % v/v	3	cd	0	c	20	b-e	0	
14	Escort XP non-ionic surfactant	1 0.25	oz wt/a % v/v	4	bcd	5	bc	25	b-e	0	
15	Escalade 2 non-ionic surfactant	48 0.25	fl oz/a % v/v	5	bc	0	c	24	b-e	0	
16	Triclopyr 3A non-ionic surfactant	48 0.25	fl oz/a % v/v	4	bcd	2	c	38	ab	0	
17	Perspective Oust Extra non-ionic surfactant	4.75 1.5 0.25	oz wt/a oz wt/a % v/v	6	b	12	b	28	b-e	0	
LSD[2] (P=.10)				2.3		8		19.2		NS	
Standard Deviation				1.7		5.7		13.6		0	
CV				41.75		148.16		54.84		0	
Replicate F				1.289		0.282		2.022		0	
Replicate Prob(F)				0.2974		0.7575		0.1585		1	
Treatment F				2.288		2.437		1.814		0	
Treatment Prob(F)				0.0425		0.0321		0.1061		1	

[1]DAA = days after application. [2]LSD = least significant difference test. Means sharing a common letter do not significantly differ at p = 0.10.NS = no significant differences present at p=0.10. Checks not analyzed.

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