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

Annual Report For FFY 2013

ODOT SP&R ITEM NUMBER 2157 Task 1

Submitted to:

John Bowman, P.E.
Planning and Research Division Engineer
Oklahoma Department of Transportation

Submitted by:

Dennis Martin, Ph.D., Principal Investigator
Clayton Hurst B.S
Oklahoma State University
Department of Horticulture & Landscape Architecture
358 Agricultural Hall
Stillwater, OK 74078

March 31, 2014

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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

Cable barrier systems are used to capture or redirect errant vehicles and reduce the severity of injuries to the traveling public. Although some ODOT vegetation managers desire vegetation in the foot prints of cross-over cable barriers, there are other situations where managers have chosen to try to keep the footprint clear of vegetation. When the managers' goals are to keep the footprint clear of vegetation, the management program can involve the use of a hard surface such as asphalt or gravel and the vegetation management program can involve mowing, string trimming and herbicide use (10,11,12,13).

In FFY 2011 the joint ODOT/OSU Roadside Vegetation Management Research effort began its focused investigation on cable barrier weed control aided by the use of herbicide programs. Three field studies were conducted each year in 2011 (10) and 2012 (11). In those trials, tank mix treatments of Diuron (diuron) plus Oust Extra (sulfometuron + metsulfuron methyl), EsplAnade (indaziflam) plus Oust Extra, and Perspective (aminocyclopyrachlor + chlorsulfuron) plus Oust XP (sulfometuron) provided the highest, most consistent level of control of summer annuals (bareground) by the end of each growing season. Those specific treatments had been able to produce and maintain at least 97% control of each of the annual weed species present provided that rainfall had occurred to activate the pre-emergent components in late winter/early spring.

Developing successful cable-barrier weed control programs while maintaining environmental sensitivity has been challenging. Many vegetation managers desire season-long vegetation control and they want to achieve this level of efficacy in a single herbicide application. However, based on past OSU-RVM program research (10,11) the findings indicate that a successful cable-barrier weed control program will most likely continue to involve at least two separate herbicide applications. Currently an effective weed control program offering acceptable environmental risk involves an early tank mix application of a preemergent and postemergent treatment in late winter or early spring followed by a summer postemergent treatment. This program keeps gravel or asphalt milling-based cable-barrier footprints nearly void of vegetation.

In previous years, several tank mix combinations have been tested. The ones that have been found to provide high levels of control for extended periods were selected to be included in two cable barrier demonstrations/research trials in calendar year 2013 (see Chapters 2 and 3). The purpose of these demonstrations was to show the strengths and weaknesses of the different treatments selected as well as the weakness in use of a single spring bareground treatment application compared to a spring bareground treatment application followed by a later late spring postemergent treatment with glyphosate herbicide.

2.0 DEMONSTRATION OF SELECTED HERBICIDE COMBINATIONS FOR THEIR ABILITY TO PROVIDE LONG-TERM RESIDUAL WEED CONTROL IN DIVISION FOUR (STUDY 4-H-15-13)

2.1 BACKGROUND

Cable barrier footprints, whether maintained with a common bermudagrass base or maintained as a bare surface, are subject to constant weed invasion. Consequently these areas require a management program to control or suppress weeds. In this demonstration/research trial, the area was being managed to be devoid of vegetation.

The soil residual herbicides chosen for demonstration in this study were considered to be “environmentally soft” at the rates selected for use in this trial. They are considered to pose acceptable environmental risk of run-off and leaching potential when used according to Federal/State label recommendations. The herbicides/rates utilized in these treatments have not been associated with high potential for runoff or down slope movement and damage to off-target vegetation. In prior research in Oklahoma they have been found to provide suitable potential for long-term (several months within one year) weed control in either a bareground or common bermudagrass type system.

The purpose of demonstration Study 4-H-15-13 was to show the effectiveness of twelve possible vegetation management programs for use in complete vegetation control in a graveled cable barrier footprint. The trial demonstrated the level of complete vegetation control one might expect when employing any single application program vs a split application/follow up program in central Oklahoma. The follow-up split application involved using a post-emergent clean up treatment for perennial weeds or escaped annual weeds in late spring. This work represented the third year of focus on vegetation management in the cable barrier footprint and a movement into demonstrating effective herbicide treatments in the management plan for a cable barrier weed control program.

2.2 OBJECTIVES

The objectives of this study were to demonstrate and continue to evaluate the control level provided by twelve different herbicide programs for complete vegetation control in a graveled cable barrier footprint during the course of the 2013 growing season.

2.3 MATERIALS AND METHODS

This non-replicated demonstration, designated as Study 4-H-15-13 was conducted on I-35, 2.9 miles north of SH-51 on the center median along the cable barrier footprint

beside the northbound lane. The soil type on the test site was a disturbed profile covered by a packed mix of varying sized gravel. The soil varied from 8 – 15 cm (3 - 6 inches) in depth from the surface. The surface of the cable barrier footprint had varying amounts of low to moderate soil deposition (siltation) present. Annual weed populations were low on this site as the cable barrier was a more recent installation and only a small amount of soil siltation was present in the footprint.

Plants present within the trial site on the initial treatment date of March 15 2013 included the following winter annual weeds: annual ryegrass [*Lolium multiflora*] and fleabane [*Erigeron sp*.]. Weeds present in the trial site on the follow up treatment date of June 14 included the summer annuals and perennial plants: fleabane [*Erigeron sp*.], prostrate spurge [*Euphorbia supina*], horseweed [*Conyza canadensis*], bermudagrass [*Cynodon dactylon*], prairie cupgrass [*Eriochloa contracta*], large crabgrass [*Digitaria sanguinalis*] and palmer amaranth [*Amaranthus palmeri*].

The specific details concerning the application site, plot size, mix size, environmental conditions and sprayer set up at the time of the March 15 and June 14, 2013 applications are shown in Table 1. Twelve different treatments, termed “bareground-type treatments” were evaluated (Table 2). Each main plot was divided into three subplots labeled A, AB, and C. Subplots A only received the initial six bareground-type treatments (residual chemicals + glyphosate) on March 15. Glyphosate in the form of Roundup Pro Concentrate was added to each initial treatment mixture at a rate of 0.98 lbs a.i. per acre to control weeds that were already emerged at the time of the initial applications. The AB subplots received the initial bareground-type treatments (residual chemicals + glyphosate) and a follow up treatment of Roundup Pro Concentrate (glyphosate) [8] at 4 quarts per acre (5 lbs a.i./Acre) on June 14 at 91 days after the initial treatments. Thus, the total number of herbicide management programs evaluated was 12 (six initial single application treatments or programs + six split application programs). The purpose of the follow up application of glyphosate to the AB subplot was to represent a program where the manager understands that often a second application is needed to control summer perennial weeds or any missed annual weeds not controlled by initial treatments. The C subplot within each plot was an untreated pair-wise check.

The residual herbicide products and their components that were tank mixed with glyphosate to form the treatments (Table 2) applied to the A subplots were Diuron (diuron) [1] plus Oust Extra (sulfometuron + metsulfuron methyl) [3], Gallery (isoxaben) [6] plus Oust Extra, Milestone VM [7] plus Oust Extra, EsplAnade (indaziflam) [2] plus Oust Extra, Prodiamine [14] plus Oust Extra and Perspective (aminocyclopyrachlor + chlorsulfuron) [5] plus Oust XP (sulfometuron) [4].

No summer annual weed species were emerged at the time of the initial herbicide treatments on March 15. Weed control data was collected at 2, 3, and 4 months after treatment (MAT). We planned to collect data up to 8 MAT. However, the study site was accidently over-sprayed by the contracted weed control company (DBI) managing the cable barrier along I-35. The incident occurred in early July and residual chemicals were

used in their management program. Because of the accidental overspray, a confounding of weed control treatments occurred and no further useful data could be collected from our original trial. On July 17 we collected the last evaluation data on this study. Data was recorded and input into Agricultural Research Manager Software (ARM). Since this demonstration was not replicated, statistical analysis is not available on data collected.

2.4 RESULTS AND DISCUSSION

The demonstration site was accidently over sprayed by representatives of private contractor DBI in early July 2013. Because of this we were only able to collect unaffected representative data up until July 17th which was 4 MAT or 124 days after the initial March 15 treatment. Although several weed species were present in the trial area, by July 17th only two major weed species were present uniformly in the trial area, prostrate spurge and prairie cupgrass, both summer annual plants. Thus, specific weed discussion in this demonstration will be confined to those two species and the data from the July 17th rating date was the most meaningful for assessment of treatment performance.

Prostrate Spurge Control

By July 17, prostrate spurge control ranged from 35 to 96 percent control (Table 3). Amongst the single application programs, the tank mix containing EsplAnade was the best treatment providing 95% control of spurge. By adding a glyphosate application to all programs on June 14, spurge control was increased to 96% - 99% control in the programs 1AB, 2AB, 3AB, 4AB, and 5AB.

Prairie cupgrass

Prairie cupgrass is a prolific seed producing summer annual native grass. It is best adapted to moist sites and thus proliferates in cable barrier footprints located in the bottom of moist center mediums, especially in the first 3 years following new construction. The three best single application programs for pre-emergent control of prairie cupgrass were those containing the Roundup Pro Concentrate + Oust Extra herbicide plus pre-emergent herbicides Diuron (treatment 1A), EsplAnade (4A) and Prodiamine (5A) [Table 3]. All three of these pre-emergent herbicides are strong grass control herbicides. Addition of the glyphosate post-emergent treatment in June at 5 lbs ai/Acre in the AB subplot programs increased prairie cupgrass control to 98 to 100% control.

Total Vegetation Control

Percent area without live vegetation (called bareground) was collected on July 17th with data shown in Table 3. Although prostrate spurge and prairie cupgrass were present in all plots there were some additional non-uniformly distributed plants that were present in the trial. The bareground rating took into account the presence of any species of plant growing in the footprint. The bareground rating is the best overall assessment parameter for measuring complete vegetation control. In the non-treated check plots, on

July 17 (4 MAT) the percent bare surface without vegetation present ranged from 40 to 67 percent. When only a single application of an herbicide tank mix program was employed in early spring, the range of area devoid of live vegetation was 58 to 98% at 4 MAT. The best single application program tested in an attempt to provide complete vegetation control as measured at 4 MAT (July 17) was program 4A. Program 4A provided 98% bareground and it consisted of EsplAnade (Indaziflam) plus Oust Extra plus Roundup Pro Concentrate. By using a follow up glyphosate treatment (two application program) on May 22, any single application program could be further improved such that it achieved 97 to 100% bareground by 4 MAT. The best two application program was that of program 4 AB which provided 100% complete vegetation control at 4 MAT.

2013 Project Steering Panel Summer Tour

The Project 2156 and 2157 steering panel toured Study 4-H-15-13 on I-35 on the afternoon of July 18, 2013 (at ~4 MAT). Twelve ODOT employees were present at this Summer Steering Panel Meeting to tour the demonstration. The weeds present as well as control level being offered at that time were reviewed with participants. We also told the panel members about the accidental overspray of the research trial by the private contractor which occurred in early July. This was the second year in a row that the private contractor over sprayed our research trial area despite our communication efforts, signage and marking of the trial site.

Table 1. Herbicide application details for experiment 4-H-15-13.

Application Factor	March 15, 2013	June 14, 2013
Time of Day:	8:15 a.m.- 8:45 a.m.	8:35 a.m.
Plot size:	7.5 feet wide X 165 feet long (55 feet in each A, AB, C subsection)	
Application Method:	Broadcast spray	Broadcast spray
Application Timing:	Pre-emergence & Post-emergence	Postemergence
Application Placement:	Soil & foliar	foliar
Air Temperature:	56 F	76 F
Relative Humidity:	70 %	88 %
Wind Velocity:	4-5 MPH	4-6 MPH
Wind Direction:	South West	South West
Dew Presence (Y/N):	No	No
Soil Temperature:	52F	82 F
Soil Moisture:	Fair/good	Good
Cloud Cover:	70%	2%
Appl. Equipment:	CO2 Bicycle Sprayer	CO2 Bicycle Sprayer
Operating Pressure:	29 PSI	29 PSI
Nozzle Type:	Teejet flat fan	Teejet flat fan
Nozzle Size:	8002VS	8003VS
Nozzle Spacing, Unit:	20 inches	20 inches
Nozzles/Row:	5	5
Boom Height:	22 inches	20 inches
Ground Speed:	1.5 MPH	2.1 MPH
Carrier:	Water	Water
Spray Volume:	30 gallons per acre	30 gallons per acre
Mix Size:	2 gallons (7.57 liters)	3 gallons (11.36 liters)
Propellant:	CO2	CO2

Table 2. Herbicide treatment tank mix components, formulations, rates and costs in experiments 4-H-15-13 and 8-H-16-13, in Divisions 4 and 8, respectively. Costs are for herbicides used in the management program applied to Subplots A and Subplot AB. [1,2]

No.	Treatment Components	Formulation of product		Product rate per acre	Active ingredient per acre	Subplot A Cost/Acre	Subplot A Cost/Mile	Subplot AB Cost/Acre	Subplot AB Cost/Mile
1	Diuron	80 %	DF	5.0 lb	4 lb	$58.65	$53.31	$76.21	$69.28
	Oust Extra	71.25 %	DG	4.0 oz wt	2.85 oz				
	Roundup Pro Concentrate	5.0 lb/gal	SL	25.0 fl oz	0.98 lb				
2	Gallery	75 %	DF	1.0 lb	0.75 lb	$149.55	$135.95	$167.11	$151.92
	Oust Extra	71.25 %	DG	4.0 oz wt	2.85 oz				
	Roundup Pro Concentrate	5.0 lb/gal	SL	25.0 fl oz	0.98 lb				
3	Milestone VM	2.0 lb/gal	SL	5.0 fl oz	1.25 oz	$41.46	$37.69	$59.02	$53.65
	Oust Extra	71.25 %	DG	4.0 oz wt	2.85 oz				
	Roundup Pro Concentrate	5.0 lb/gal	SL	25.0 fl oz	0.98 lb				
4	EsplAnade	1.67 lb/gal	SC	5.0 oz	1.04 oz	$69.84	$63.49	$87.40	$79.45
	Oust Extra	71.25 %	DG	4.0 oz wt	2.85 oz				
	Roundup Pro Concentrate	5.0 lb/gal	SL	25.0 fl oz	0.98 lb				
5	Prodiamine	65 %	DG	2.3 lb	1.5 lb	$51.05	$46.41	$68.61	$62.37
	Oust Extra	71.25 %	DG	4.0 oz wt	2.85 oz				
	Roundup Pro Concentrate	5.0 lb/gal	SL	25.0 fl oz	0.98 lb				
6	Perspective	55.3 %	SG	8. oz wt	4.42 oz	$57.97	$52.70	$75.53	$68.66
	Oust XP	75 %	DG	3.0 oz wt	2.25 oz				
	Roundup Pro Concentrate	5.0 lb/gal	SL	25.0 fl oz	0.98 lb				

[1]Footnotes: SL=soluble liquid, SC=soluble concentrate, WG=water dispersible granule, and DF=dry flowable.

[2]Cost is the total cost of herbicide tank mix components only. Costs of Diuron, Oust, and Oust Extra were provided by Winfield Solutions on 24 March 2014. Costs for Milestone, Perspective, Prodiamine and Roundup Pro Concentrate were from the State Wide Contract. EsplAnade 200 SC cost is that of the agency price set by Bayer Environmental Science. Subplot A cost was for tank mix applied on March 15 while costs associated with subplot AB was the costs associated with the A subplot plus a “B” follow up glyphosate application on May 22 in Study 8-H-16-13 and on June 14 in Study 4-H-15-13 at 5 lbs ai/acre. Lane mile assumed a single 7.5 ft wide cable barrier footprint in the median.

Table 3. Comparison of soil residual-type herbicide combinations for preemergence control of palmer amaranth in Study 4-H-15-13. Tank mixes were applied to A and AB subplots on March 15 with subplots AB treated with glyphosate on June 14, 2013.

Treatment name	Product rate per acre		Percent bareground Jul-17-2013	Percent control of prostrate spurge Jul-17-2013	Percent control of prairie cupgrass Jul-17-2013
1 Diuron	5.0	lb	75.0	70.0	90.0
Oust Extra	4.0	oz wt			
Roundup Pro Concentrate	25.0	fl oz			
1. Section AB Follow up Treatment Roundup Pro Concentrate 4 qt			99.0	99.0	98.0
2 Gallery	1.0	lb	62.0	75.0	45.0
Oust Extra	4.0	oz wt			
Roundup Pro Concentrate	25.0	fl oz			
2. Section AB Follow up Treatment Roundup Pro Concentrate 4 qt			99.0	99.0	99.0
3 Milestone VM	5.0	fl oz	62.0	50.0	35.0
Oust Extra	4.0	oz wt			
Roundup Pro Concentrate	25.0	fl oz			
3. Section AB Follow up Treatment Roundup Pro Concentrate 4 qt			99.0	99.0	100.0
4 EsplAnade	5.0	oz	98.0	96.0	99.0
Oust Extra	4.0	oz wt			
Roundup Pro Concentrate	25.0	fl oz			
4. Section AB Follow up Treatment Roundup Pro Concentrate 4 qt			100.0	99.0	100.0
5 Prodiamine	2.3	lb	72.0	35.0	100.0
Oust Extra	4.0	oz wt			
Roundup Pro Concentrate	25.0	fl oz			
5. Section AB Follow up Treatment Roundup Pro Concentrate 4 qt			99.0	96.0	100.0
6 Perspective	8.0	oz wt	58.0	35.0	20.0
Oust XP	3.0	oz wt			
Roundup Pro Concentrate	25.0	fl oz			
6. Section AB Follow up Treatment Roundup Pro Concentrate 4 qt			97.0	80.0	98.0
1 Section C Untreated Check			56.0	55.0	35.0
2 Section C Untreated Check			43.0	45.0	30.0
3 Section C Untreated Check			80.0	5.0	35.0
4 Section C Untreated Check			40.0	20.0	25.0
5 Section C Untreated Check			62.0	25.0	20.0
6 Section C Untreated Check			67.0	35.0	25.0

3.0 DEMONSTRATION OF SELECTED HERBICIDE COMBINATIONS FOR THEIR ABILITY TO PROVIDE LONG-TERM RESIDUAL WEED CONTROL IN DIVISION EIGHT (STUDY 8-H-16-13)

3.1 BACKGROUND

Please see section 2.1 for general background information on this and the identical demonstration identified as Study 4-H-15-13 conducted on I-35. The purpose of demonstration Study 8-H-16-13 was to show the effectiveness of twelve vegetation management programs for use in complete vegetation control in a graveled cable barrier footprint in east central Oklahoma. The trial demonstrated the level of complete vegetation control one might expect when employing any single application program vs a split application program (meaning second follow up treatments involved) in east central Oklahoma. The second applications involved a post-emergent clean up treatment of glyphosate in mid spring for control of perennial weeds or escaped annual weeds.

3.2 OBJECTIVE

The objectives of this study were to demonstrate and continue to evaluate the control level provided by twelve different herbicide programs for complete vegetation control in a graveled cable barrier footprint during the course of the 2013 growing season.

3.3 MATERIALS AND METHODS

This herbicide program demonstration was conducted in Pawnee County on US-Highway 412, 0.2 miles east of 296 West Avenue, in the center median along the cable barrier footprint. The application specifics including dates/times of application, plot size, environmental conditions, and sprayer set up are shown in Table 4. The soil type on the test site was a native soil, 3 - 6 inches in depth below the surface packed gravel layer. The surface of the cable barrier footprint had varying amounts of soil siltation on top of the packed gravel. This siltation allowed for a site of weed infestation. Weed populations were considered high and fairly even throughout the entire study area. Weeds present within the trial site on the initial treatment date of March 15 2013 included: Downy brome [*Bromus tectorum*] annual ryegrass [*Lolium multiflora*], large hop clover [*Trifolium campestre*], and Sowthistle [*Sonchus sp*.]. Not all weeds occurred uniformly throughout the trial area so comparative control ratings were not possible on all species. Weeds present in the trial site on the follow up treatment date of May 22 included the following summer annuals and perennial plants: daisy fleabane [*Erigeron sp*.], nodding spurge [*Euphorbia nutans*], prostrate spurge [*Euphorbia supine*], horseweed also known as mare's tail [*Conyza canadensis*], johnsongrass [*Sorghum halepense*], switchgrass

[*Panicum virgatum*], bermudagrass [*Cynodon dactylon*], silver bluestem [*Andropogon saccharoides*], Illinois bundleflower [*Desmanthus illinoesis*] large crabgrass [*Digitaria sanguinalis*], and palmer amaranth [*Amaranthus palmeri*].

This demonstration did not contain any treatment replications. In this manner we were able to put out much longer plots in hope of having more uniform weed populations to evaluate and show to any attendees visiting the test site. Each demonstrated program included three subplot sections labeled A, AB, and C. The A labeled subplots only received the initial herbicide treatments that contained the tank mix of a complete vegetation control type herbicide plus Roundup Pro Concentrate (glyphosate) at 25.0 fl oz/A (0.98 lbs a.i./A) [Table 5]. The subplots labeled AB received the initial tank mix of a bareground type treatment associated with the A subplot plus the Roundup Pro Concentrate (glyphosate) herbicide at 4 quarts of product per acre (5.0 lbs a.i/A) at 61 days after the initial treatment. The purpose of the addition of glyphosate to each initial treatment mixture was to control weeds that were already emerged at the time of the initial herbicide applications. The follow up application of the glyphosate alone on May 22 was critical for demonstrating the difficulty of controlling established perennial weeds within areas that had received the initial application administered to the A and AB subplots. The subplots labeled C were specific location pair-wise untreated checks located immediately adjacent to their respective A and AB subplots. This pair-wise arrangement of treatments helped the evaluator and those viewing the demonstration discern actual treatment differences in areas where weed pressure was variable within the demonstration (experimental) area.

No summer annual weed species were emerged at the time of the initial residual herbicide treatments made on March 15. Weed control data was collected at 2, 3, 4, 6 and 8 months after the initial treatment (MAT). Data was recorded and input into Agricultural Research Manager Software version 8 (ARM) [Gylling Data Management, Inc., http://www.gdmdata.com/]. Since this demonstration contained treatments that were not replicated, statistical analysis was not possible.

3.4 RESULTS AND DISCUSSION

Marestail populations were low and erratic within the study area. However, attempts were made to collect some level of useful control observations. All 12 herbicide treatments provided excellent marestail control throughout the duration of this study (data not shown). Each of these treatments maintained complete or near complete (100%) control of marestail. Marestail is one of the taller weeds that occur in cable barrier foot print areas, so having successful control of it is very important.

Ratings for the percentage of area having no vegetation present (bareground) were made up to 8 months after initial treatment (MAT) at the end of the annual growing season during November. Ratings of percent bare plot area at 4 MAT (July 16), 6 MAT (Sept 18) and 8 MAT (Nov 25) are shown in Table 5. The data shown for those three rating dates were collected at 2, 4 and 6 months after the followup glyphosate treatment

that was administered on May 22nd.

The worst total vegetation control provided by any single application tank mix at 4 MAT was from programs 3A and 6A (Table 5) with only 45 and 28% bare area provided by these programs, respectively. At 4 MAT the best single application programs were programs 4A and 5A which provided 83 and 80% bare area. Even so, 17% vegetation coverage is generally unsatisfactory were complete vegetation control is desired. Concerning vegetation control with the split application treatments, at 4 MAT the worst performing program was program 6AB with the remaining five split application programs providing 92 to 98% bareground at 4 MAT.

While ratings were taken at 8 MAT (November 25), frosts had occurred on the test site by that time so low temperature injury to vegetation was contaminating the data and confounding interpretation. Thus, the 6 MAT rating in September better represented an end of growing season rating prior to the occurrence of freeze injury on weed populations. By the September rating date (6 MAT) the percent bareground in the untreated check plots was 3 to 20%, a 6.7 fold range in vegetative cover. This illustrates the high natural variability that is present within the highly silted cable barrier footprint and why the coefficients of variation in weed populations and consequently, weed control, are often so high in these types of field trials. We chose not to condition the weed control data for the variability in vegetation cover in the check plots. Often such procedures can induce their own anomalies into the analysis as well as reduce the effects from other anomolies. At 6 MAT the worst performing single application programs and their respective percentage area of bareground provided in parentheses were: 6a (17%), 3a (40%) and 5a (50%). The best single application programs at 6 MAT were programs 1A, 2A and 4A at 70, 70 and 80% bareground, respectively. The worst performing split-application programs were 6AB and 3AB at 55 and 65% bareground, respectively. The best two-part split application programs at 6 MAT were those of 1AB and 4AB which provided 90 and 93% bareground, respectively. It is important for us to again mention that the demonstration plots were not replicated so we can only illustrate the simple numeric differences present in the percent bareground present within the treated subplots and statistical comparisons are not possible in this type of non-replicated large plot demonstration.

4.0 SUMMARY AND CONCLUSIONS

We conducted two non-replicated demonstrations of 12 weed control programs in 2013. The two demonstrations targeted complete vegetation control in the cross over cable barrier footprint. The trials were conducted in Division Four on I-35 (Study 4-H-15-13) and on US 412 in Division Eight (Study 8-H-16-13) near Pawnee. The programs that were demonstrated were developed from a collection of treatments evaluated in two prior year's work funded by the ODOT SP&R program in prior 2157 Projects. The 12 programs tested consisted of six programs that involved a late winter/early spring tank mix of both pre and postemergent herbicides. The other six programs involved not only the early season tank mix application but a mid-growing season application of a high end labeled rate of glyphosate herbicide (5 lbs ai/A) to kill escaped vegetation present at that time. The second application represented either a broadcast mid-season application or a spot treatment to be used if sporadic weed breakthroughs were present. The treatments that we chose to include in these 12 programs were those that we felt had 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. In past trials, tank mix treatments of Diuron (diuron) plus Oust Extra (sulfometuron + metsulfuron methyl), EsplAnade (indaziflam) plus Oust Extra, and Perspective (aminocyclopyrachlor + chlorsulfuron) plus Oust XP (sulfometuron) have provided the highest, most consistent level of control of summer annuals (bareground) by the end of each growing season. Those specific treatments had been able to produce and maintain at least 97% control of each of the annual weed species present in prior years' trials provided that rainfall had occurred to activate the pre-emergent components in late winter/early spring.

The bareground rating is the best overall assessment parameter for measuring complete vegetation control in simple field research trials. In study 8-H-16-13 at 6 months after treatment (MAT) the best single application programs were a tank mix of Diuron at 5 lb/A + Oust Extra at 4.0 oz/A + Roundup Pro Concentrate at 25 fl oz/A [Program 1A] ($58.65/A to produce 70% bareground); Gallery at 1.0 lbs/Acre + Oust Extra at 4.0 oz/A + Roundup Pro Concentrate at 25 fl oz/A [Program 2A] ($149.55/A to produce 70% bareground); and EsplAnade at 5 fl oz/A + Oust Extra at 4.0 oz/A + Roundup Pro Concentrate at 25 fl oz/A [Program 4a] ($69.84/A to produce 80% bareground), respectively. Unfortunately, none of the single application programs tested could provide more than 80% bareground by 6 MAT.

The best performing two-part split application programs demonstrated in 8-H-16-13 when viewed at 6 MAT were the Program 1AB which was Diuron + Oust Extra + Roundup Pro Concentrate applied early with a high rate of Roundup Pro Concentrate applied mid-season ($76.21/A to produce 90% bareground) and the Program 4AB which consisted of the early tank mix of EsplAnade + Oust Extra + Roundup Pro Concentrate with a high rate of Roundup Pro Concentrate applied mid-season ($87.40/A to produce 93% bareground), respectively.

Study 4-H-15-13 on I-35 was accidently over sprayed by a private contractor (for the

second year in a row) with a glyphosate plus residual herbicide tank mix in early July. We felt that our trial had been appropriately marked and that the private contractor had been adequately notified as to the location and markers used to designate our trial. As a consequently of the accidental overspray, that demonstration could only be monitored for performance of our protocol treatments until July 17th (4 MAT). The best single application program tested in an attempt to provide complete vegetation control as measured at 4 MAT was Program 4A which consisted of EsplAnade (Indaziflam) plus Oust Extra plus Roundup Pro Concentrate and it provided 98% bareground at a cost of $69.84/A. By using a follow up glyphosate treatment (two application program) at 4 quarts/A on May 22, any single application program could be further improved such that it achieved 97 to 100% bareground by 4 MAT with an added cost of only $17.56 per acre in glyphosate herbicide costs. The best two application program was that of program 4 AB which consisted of the EsplAnade + Oust Extra + Roundup Pro Concentrate tank mix, applied in early spring with a mid-season Roundup Pro Concentrate application which provided 100% bareground or complete vegetation control at 4 MAT for a total program herbicide cost of $87.40/A.

We are aware that ODOT vegetation managers would like to have a highly effective single application program to achieved season-long weed control. A successful single application made in late spring would allow ODOT staff to focus on numerous other tasks for which they are responsible. However, we have not found any herbicide choices or combinations at rates which provide 100% weed control in gravel cable barrier footprints for a 6 to 8 month period every year AND that provides acceptable risks for non-target environmental effects such as leaching, runoff and volatility. We believe that split application programs are currently required with the herbicide products commercially available to ODOT vegetation managers at this time.

It is important to note that this report is an annual report and recommendations from the findings of three years of research on cable barrier weed management have not been finalized. Final recommendations are made from such work in a final report, in updates to OSU publication E-958: *Suggested Maintenance Practices for Roadside Weed and Brush Problems*, in topics covered at annual pesticide applicator continuing education programs (CEU Workshops) and through personal consultations to ODOT vegetation mangers. Work on this topic area will continue during FFY 2014 as a part of SP&R Item 2157 with a final report on the subject matter expected in fall of 2014.

Table 4. Herbicide application specifics for experiment 8-H-16-13 on two treatment dates (March 15 and May 22, 2013).

Application Factor	Mar-15-2013	May-22-2013
Time of Day:	10:50 a.m. -12:00 p.m.	9:15 a.m. - 9:00 a.m.
Plot size:	7.5 feet X 165 feet (55 feet in each A, B, C section)	7.5 feet X 55 feet
Application Method:	Broadcast spray	Broadcast spray
Application Timing:	Preemergence & Postemergence	Postemergence
Application Placement:	Soil & foliar	foliar
Air Temperature:	68 F	74 F
Relative Humidity:	58 %	66 %
Wind Velocity:	4-5 MPH	2-5 MPH
Wind Direction:	West	N
Dew Presence (Y/N):	No	No
Soil Temperature:	64 F	68 F
Soil Moisture:	Good	Very Good
Cloud Cover:	20%	0%
Appl. Equipment:	CO2 Bicycle Sprayer	CO2 Bicycle Sprayer
Operating Pressure:	29 PSI	29 PSI
Nozzle Type:	Teejet flat fan	Teejet flat fan
Nozzle Size:	8002VS	8002VS
Nozzle Spacing, Unit:	20 inches	20 inches
Nozzles/Row:	5	5
Boom Height:	22 inches	28 inches
Ground Speed:	1.5 MPH	1.5 MPH
Carrier:	Water	Water
Spray Volume:	30 gallons per acre	30 gallons per acre
Mix Size:	2 gallons (7.57 liters)	3 gallons (11.36 liters)
Propellant:	CO2	CO2

Table 5. Comparison of soil residual-type herbicide combinations for preemergence control of palmer amaranth in Study 8-H-16-13. Tank mixes were applied to A and AB subplots on March 15 with subplots AB treated with glyphosate on May 22, 2013.

Treatment Name	Product rate per acre		Percent Bareground Jul-16-2013 4 MAT	Percent Bareground Sep-18-2013 6 MAT	Percent Bareground Nov 25-2013 8 MAT
1 Diuron	5.0	lb	72.0	70.0	88.0
Oust Extra	4.0	oz wt			
Roundup Pro Concentrate	25.0	fl oz			
1. Section AB Follow up Treatment Roundup Pro Concentrate 4 qt			94.0	90.0	85.0
2 Gallery	1.0	lb	75.0	70.0	92.0
Oust Extra	4.0	oz wt			
Roundup Pro Concentrate	25.0	fl oz			
2. Section AB Follow up Treatment Roundup Pro Concentrate 4 qt			98.0	80.0	90.0
3 Milestone VM	5.0	fl oz	45.0	40.0	90.0
Oust Extra	4.0	oz wt			
Roundup Pro Concentrate	25.0	fl oz			
3. Section AB Follow up Treatment Roundup Pro Concentrate 4 qt			92.0	65.0	90.0
4 EsplAnade	5.0	oz	83.0	80.0	95.0
Oust Extra	4.0	oz wt			
Roundup Pro Concentrate	25.0	fl oz			
4. Section AB Follow up Treatment Roundup Pro Concentrate 4 qt			98.0	93.0	97.0
5 Prodiamine	2.3	lb	80.0	50.0	95.0
Oust Extra	4.0	oz wt			
Roundup Pro Concentrate	25.0	fl oz			
5. Section AB Follow up Treatment Roundup Pro Concentrate 4 qt			98.0	85.0	95.0
6 Perspective	8.0	oz wt	28.0	17.0	35.0
Oust XP	3.0	oz wt			
Roundup Pro Concentrate	25.0	fl oz			
6. Section AB Follow up Treatment Roundup Pro Concentrate 4 qt			64.0	55.0	58.0
1 Section C Untreated Check			20.0	20.0	20.0
2 Section C Untreated Check			13.0	8.0	5.0
3 Section C Untreated Check			13.0	15.0	10.0
4 Section C Untreated Check			18.0	3.0	7.0
5 Section C Untreated Check			7.0	10.0	10.0
6 Section C Untreated Check			4.0	3.0	4.0

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