EVALUATION OF HERBICIDE AND ADJUVANT PHYSICAL COMPATIBILITY

Annual Report For FFY 2012

ODOT SP&R ITEM NUMBER 2157

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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

The Oklahoma Department of Transportation (ODOT) uses an integrated roadside vegetation management (IRVM) strategy that incorporates mechanical, cultural, and biological practices in addition to herbicides to effectively manage roadside vegetation. Herbicides are a vital component of ODOT's IRVM strategy and will likely stay that way for the foreseeable future. The U.S. Environmental Protection Agency (US EPA) regulates pesticide registration in the U.S. Along with the Oklahoma Department of Agriculture, Food, and Forestry (ODAFF), US EPA directly and indirectly controls the availability of herbicides for vegetation managers in Oklahoma. Currently the US EPA and ODAFF do not regulate pesticide adjuvants sold separately from or as a part of the pesticide formulated products. Adjuvants are products that improve the performance characteristics of a pesticide and/or its application. For many years ODOT used the adjuvant Detain II® (1). Detain II® is a deposition aid and drift retardant. While effective, it was a product that was difficult to handle and mix due to its short shelf life and instability issues. During 2011, Herbicide and Adjuvant Physical Compatibility Tests were conducted on the products Control™ (2) and Corral® Poly (3). Both were found to be suitable replacements for Detain II® with qualifications. ODOT can use either the Control™ or Corral® Poly product to improve herbicide spray characteristics and reduce the potential for off-target particle drift for most herbicides. During the 2011 testing, the Control™ product was found to be compatible with all herbicides tested. Only a single incompatibility was found between the Corral® Poly product and herbicides, that being when mixed with Prodiamine 65 WDG herbicide (4). Both Control™ and Corral® Poly can be effective drift control products by decreasing the number of small spray particles of 100 microns or less in diameter and thus reducing the likelihood of "off-target particle drift."

The lack of close regulation of adjuvants as well as the lack of published data on the physical compatibility of herbicide's and adjuvants allows for possible unknown physical tank mix incompatibilities to exist. Compatibility testing of herbicide/adjuvant tank mix partners helps the ODOT guard against unidentified and potentially costly issues of physical incompatibility between new or reformulated herbicides and adjuvants.

Adverse consequences of physical incompatibility can include settling, layer formation, globule formation or formation of precipitants. If these issues occur, they can damage or clog sprayer components. Incompatible mixes may even affect an herbicide's performance in terms of weed control. In the event of a tank mix of incompatible herbicides and adjuvants, the applicator would then have to deal with disposal of the material in a legal manner. Applying the incompatible mixture to the roadside may not be an option if sprayer components are clogged or if the incompatible mixture cannot be accurately applied. This may result in ODOT being forced to dispose of the tank mix as a hazardous waste material. Obviously the latter option is very undesirable.

The Oklahoma State University Roadside Vegetation Management (OSU-RVM) Program is under contract by ODOT to annually test the physical compatibilities of new herbicide's and adjuvants intending to be added to the *ODOT Approved Herbicide and Adjuvant List* (AHAL). The intent of this effort is to place only those new products on the AHAL that have proven tank mix compatibility. This ultimately will prevent ODOT herbicide applicators from being in the position of dealing with a tank of incompatible herbicide waste in the future. As long as ODOT continues to only use those herbicides and adjuvants that are on the current AHAL and provided suitable tank agitation is present, we are confident there should be no tank mix physical incompatibility issues.

2.0 PROBLEM STATEMENT

In 2012 there were no new adjuvants (drift control products) in need of physical compatibility testing for ODOT. However, the newly labeled herbicide Esplanade™ 200 SC, currently being screened as a possible long-term residual herbicide for weed control in ODOT cable barrier systems, was in need of compatibility testing. Esplanade 200 SC has shown promise in 2011 & 2012 OSU Roadside Weed Control Research Trials. It is very likely that formal recommendations on its use will come from OSU in 2013. Esplanade™ 200 SC will likely be tank-mixed with one or more other herbicides and applied as a broadcast or handgun herbicide treatment under cable-barriers, guardrails, sign posts, and other bareground areas along roadsides. Because of the broadcast-type herbicide treatment, it will be required that a drift control adjuvant must be used with the product application under ODOT Policy No. D-504-1 [effective 1-31-2011] (5). This necessitates testing of physical tank mix compatibility of Escalade™ 200 SC with both Control™ and Corral® Poly adjuvants.

3.0 PURPOSE OF RESEARCH

The purpose of this research was to test the physical compatibility of Control™ Deposition Aid/Drift Retardant and Corral® Poly Drift Control Agent and Deposition Aid [Figure 1] when mixed with Esplanade™ 200 SC herbicide. If found compatible, the next AHAL could be modified with findings from this research.

4.0 STUDY OBJECTIVES

Using an industry standard jar test, the specific objectives of this research were to test the physical compatibility of selected treatments of:

i) Control™ (Polyvinyl Polymer (Polyacrylamide) with Esplanade™ 200 SC.

ii) Corral® Poly (Polyvinyl Polymer (Polyacrylamide) with Esplanade™ 200 SC.

5.0 MATERIALS AND METHODS

The tank mix compatibility testing was conducted on 1 August 2012 from 1:00 to 2:30 p.m. at the Turfgrass Research Center located at the Oklahoma Botanical Garden, Oklahoma State University, Stillwater, OK. Control™ and Corral® Poly brand products were investigated for physical compatibility with Esplanade 200 SC herbicide (Table 1, Figure 1). Control™ and Corral® Poly are polyvinyl polymer drift control additives that when used properly can help reduce the potential for off-target particle drift. Using some type of drift control product is very important in all broadcast herbicides applications and is required effective 1-31-2011 under ODOT Policy No. D-504-1 (5). By this policy, a drift control product must be used in each broadcast or powered handgun herbicide application made by ODOT personnel.

A tank mix carrier rate of 30 gallons per acre (GPA) was used in this test for all treatments. The 30 GPA carrier rate is commonly used by many ODOT personnel for making broadcast herbicide applications. An industry standard jar test method was used for tank mix compatibility testing (4, 6). Clear, clean, unused 1-liter soda bottles were filled with 500 ml of deionized water. The deionized water had a pH of 5.6 with minimal amounts of cations and anions present (Appendix A). The lack of calcium and magnesium resulted in classification of this carrier as “soft” (7). The appropriate herbicide amounts and Surf-King Plus Non-ionic Surfactant (8) were added to each bottle to represent OSU recommended broadcast herbicide treatment rates for the specific herbicides and manufacturer recommended rates for Control™ and Corral Poly®. Specific herbicide treatments and treatment rates that were tested are listed in Table 1. Specific drift control product rates tested are listed in Table 2.

Laboratory experimental conditions were maintained under relatively controlled environmental conditions where the mean air temperatures were 80 - 82 ^{o}F (precision $\pm$ 1 ^{o}F, accuracy $\pm$ 0.2 ^{o}F.) and deionized water temperatures were 80 - 81 ^{o}F (precision $\pm$ 1 ^{o}F, accuracy $\pm$ 0.2 ^{o}F). Air and water temperatures were measured with calibrated mercury in glass thermometer and read to the nearest 1.0 ^{o}F.

Treatments were evaluated at three separate stages following mixing (see Appendix B) to determine if any physical incompatibilities were produced and sustained. Once all herbicide/adjuvant components were mixed properly, initial evaluations were made immediately after the initial mixing, followed by evaluations at 30 minutes after initial mixing but prior to remixing. Final evaluations were taken immediately following the 30

minute rating but after remixing. Four questions were asked at each stage of the evaluation (see Appendix C) to assess any visual physical incompatibilities. The visual physical incompatibilities assessed were: formation of precipitates, layering, flocculation and foaming. Bottles were backlit with a light source to make incompatibilities more evident, if present. The experiment was designed as a Randomized Complete Block with 2 replications of treatments.

Table 1. Herbicide and adjuvant treatments evaluated for physical compatibility during 2011 testing.[1]

Treatment Number & Product Names		Form Conc[1]	Form Unit	Form Type	Rate	Rate Unit	Carrier Rate
1	Esplanade™ 200 SC +	1.67	lb ai/gal	SC	5.0	fl oz/a	30
	Surf King non-ionic surfactant	90	%	L	0.25	% v/v	

1Form = Formulation, Conc. = Concentration, lb ai = pounds of active ingredient, gal=gallons, fl oz = fluid ounces, v=volume of product to volume of water ratio, a = acres. L=liquid, and SC=soluble concentrate.

Table 2. Selected drift control products, rates, and carrier rates evaluated for physical compatibility with selected ODOT herbicides and herbicide combinations[1].

Treatment Number & Product Names		Active Ingredient Concentration by Weight (%)	Formulation Type	Product Use Rate	Spray Carrier Rate
1	Control™	37	L	1 fl oz/100 gal	30
2	Corral® Poly	30	L	2 fl oz/100 gal	30

[1]L=liquid, fl oz = fluid ounces, gal = gallons.

6.0 RESULTS

During the 2012 compatibility testing both Control™ and Corral® Poly (Table 2) adjuvants proved to be compatible with Esplanade 200 SC (Table 1). The new herbicide, Esplanade™ 200 SC, having a relatively low active ingredient concentration per gallon of formulation, mixed very easily and quickly in water. Both Control™ and Corral Poly® also mixed completely and easily with the herbicide and water mixture.

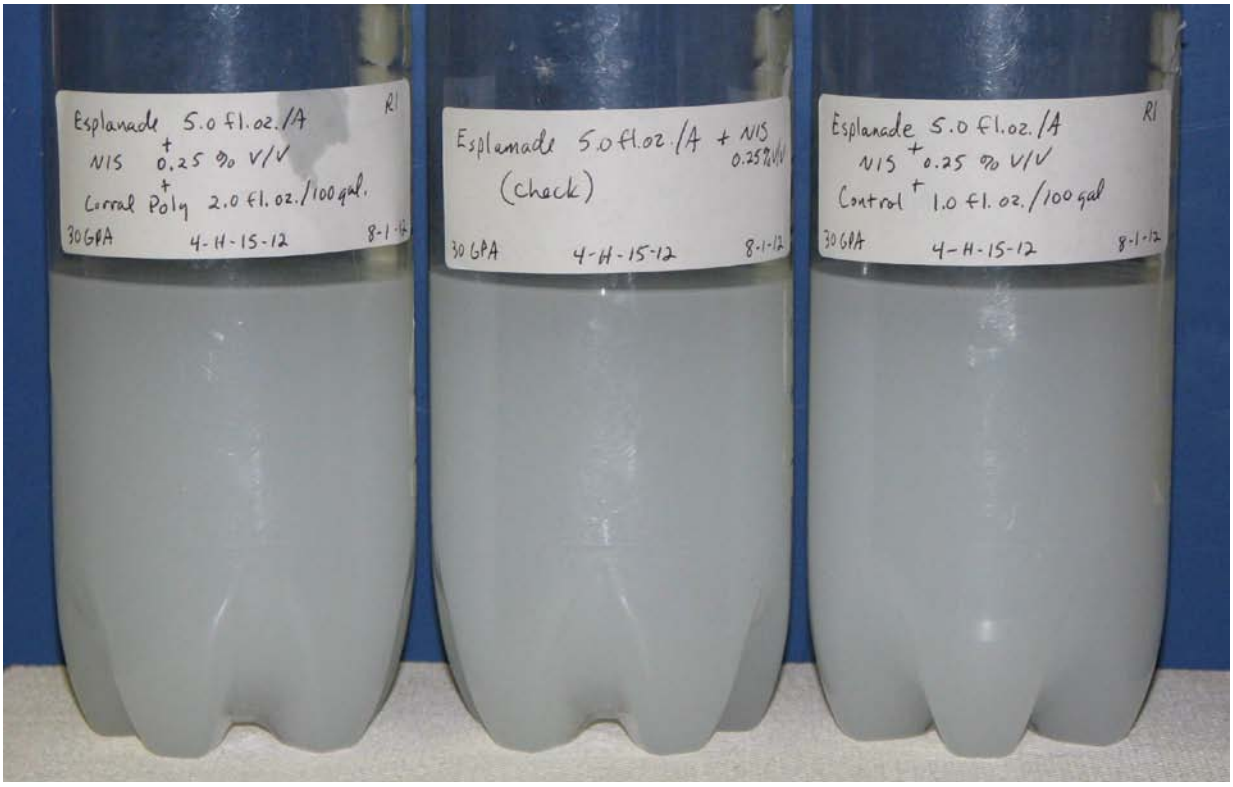

Figure 1. Compatible mixture of Esplanade™ 200 SC and Corral® Poly (bottle on far left) and Control™ mixture in the far right bottle. Bottle in the middle is a controlled check with only Esplanade® 200 SC and non-ionic surfactant.

7.0 DISCUSSION

Our testing can be considered to represent a conservative approach. We are confident that this testing method would detect physical incompatible tank mix combinations that could be problematic to the ODOT RVM Managers under field conditions. Provided that labeled directions are followed and characteristics of water carrier sources are not extreme, we do not feel that the Control™ Deposition Aid/Drift Retardant at 1.0 oz./100 gallons carrier rate or the Corral® Poly Drift Control Agent and Deposition Aid at 2.0 oz./100 gallons carrier rate will cause any physical incompatibility problems for ODOT personnel if and when they choose to incorporate the herbicide Esplanade™ 200 SC into their programs.

8.0 CONCLUSIONS

1. Use of Esplanade™ 200 SC (Table 1) with Control™ Deposition Aid/Drift Retardant at 1.0 oz./100 gallons of water or Corral® Poly at the 2.0 oz./100 gallons of water are not expected to create any tank mix combination that are unusable as long as labeled directions are followed and characteristics of water carrier sources are not extreme.

9.0 LIMITATIONS ON CONCLUSIONS

Our compatibility testing is only for physical tank mix incompatibility that can be detected via a visual industry standard jar test (4, 6). ODOT herbicide applicators are required to read all herbicide label information concerning water carrier issues and to be familiar with the water sources they are using. ODOT applicators can reference the OSU RVM Programs report *2005 Evaluation of ODOT Water Quality Characteristics for Suitability in Herbicide Spray Applications* (9) to determine specific characteristics of water sources tested. Additionally, we encourage periodic testing of water sources, especially if water sources change from previous sources. During periods of extended drought, water sources can experience changes in qualitative and quantitative properties, dictating a need for retesting.

10.0 RECOMMENDATIONS

Considering the positive compatibility results, the OSU-RVM Program recommends that Esplanade™ 200 SC be included in the next *ODOT Approved Herbicide & Adjuvant List (AHAL)* that is produced. We also recommend the end user read the section of this report on “LIMITATIONS ON CONCLUSIONS” as well as read and follow all product label directions.

11.0 REFERENCES

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APPENDIX A

DEIONIZED WATER ANALYTICAL LABORATORY REPORT

Soil, Water & Forage Analytical Laboratory

Oklahoma State University Division of Agricultural Sciences and Natural Resources
045 Agricultural Hall
Stillwater, OK 74078
E-mail: soiltesting@okstate.edu
Website: www.soiltesting.okstate.edu

WATER QUALITY REPORT

ROADSIDE VEGETATION MGMT PROGR...
358 AG HALL

STILLWATER, OK 74078

Name :

Location :

Lab ID No.: : 656292
Customer Code : 216
Sample No. : 4191
Received : 8/2/2012
Report Date : 8/10/2012

Test Results for Irrigation Water

---------- Cations ----------		---------- Anions ----------		---------- Other ----------	
Sodium (ppm)	1	Nitrate-N (ppm)	<1	pH	5.6
Calcium (ppm)	1	Chloride (ppm)	1	EC (µmhos/cm)	10.3
Magnesium (ppm)	0	Sulfate (ppm)	0		
Potassium (ppm)	0	Boron (ppm)	<.01		
		Bicarbonate (ppm)	5		

---------- Derived Values ----------		-------- Derived Values(cont'd) ----------	
Total Soluble Salts (TSS in ppm)	8.1	Sodium Percentage	
Sodium Adsorption Ratio (SAR)	0.2	Hardness (ppm)	1.7
Potassium Adsorption Ratio (PAR)	0	Hardness Class	Soft
Residual Carbonates (meq)	0.1	Alkalinity (ppm as CaCO3)	4.3

INTERPRETATION AND REQUIREMENTS FOR *Irrigation Water*

The total soluble salt and sodium content of this water are low enough that no problem should result from its use.

Signature

APPENDIX B

PROCEDURES FOR CONDUCTING HERBICIDE AND ADJUVANT PHYSICAL COMPATIBILITY TEST

Procedures for Conducting Herbicide and Adjuvant Physical Compatibility Test

1. Mix all herbicides together in the simulated spray tank (bottle) first, before attempting to add any adjuvant. The mixing order of products should follow the guidelines given below.

Mixing order for herbicides:

a. Ammonium sulfate (AMS)

b. dry herbicides

c. liquid solubles

d. liquid emulsifiables

e. adjuvants

Mixing should occur by slowly inverting bottle 3 or 4 times (no shaking) after each product is added. This should be adequate to mix all liquids but dry herbicides may require repeating the inversion process several more times over a 1-3 minute period or until all dry herbicide prills are visibly dispersed. Inverting bottles should be performed to prevent excessive foaming if at all possible. All herbicides & AMS should be thoroughly mixed before attempting the addition of any adjuvants being tested.

2. Add the appropriate adjuvants to the herbicide mixture one at a time followed by slowly inverting the mixture 10 times. Evaluate the mixture immediately and move on to the next adjuvant, repeating the process. Once the first mixture is evaluated, make a note of the time on the score sheet. Once all evaluations are made with a particular herbicide treatment, allow the bottles to set undisturbed for 30 minutes (or as close as possible).

3. After 30 minutes evaluate each of the bottles for the 2nd time. It is acceptable to pick up the bottles, but this should be done carefully so as not to disturb the mixture. After evaluation, place each bottle down undisturbed. It might be helpful to hold the mixture with a bright light (light bulb, window) behind the bottle to backlight the mixture making possible incompatibilities more visible. When the last mixture is evaluated proceed immediately to the 3rd evaluation.

4. The 3rd and final evaluation occurs by slowly inverting the first bottle 10 times followed by evaluation.

5. Each herbicide treatment will have 3 evaluation sheets, one sheet for each evaluation timing. When evaluations are completed, staple the 3 evaluation sheets together.

APPENDIX C

PHYSICAL COMPATIBILITY TEST DATA COLLECTION FORM

Physical Compatibility Test Data Collection Form. 2012.

Herbicide Treatment & Number:											Date/Evaluator:						
			1. Were precipitates formed?					2. Were separate layers formed?			3. Did herbicide mixture flocculate?			4. Was there a change in			5. Other?
Adjuvant	Rep	Evaluation	No	flakes	colored	clear	sludge	No	suspend	settled	No	suspend	settled	No	more	less	
None	1	1															
None	1	2															
None	1	3															
Control	1	1															
Control	2	1															
Control	1	2															
Control	2	2															
Control	1	3															
Control	2	3															
Corral Poly	1	1															
Corral Poly	2	1															
Corral Poly	1	2															
Corral Poly	2	2															
Corral Poly	1	3															
Corral Poly	2	3															