2007 Report on
The Evaluation of Herbicide/Adjuvant Tank Mix Compatibility

Produced Under Project 2157 Section 3

A Joint Project Between
the Oklahoma Department of Transportation
and Oklahoma State University

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The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the views of the Oklahoma Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification or regulation.

In order that the information in this publication may be more useful, it was necessary to use trade names of products, rather than chemical names. As a result, it is unavoidable in some cases that similar products that are on the market under other trade names may not be cited. No endorsement of products is intended nor is criticism implied of similar products that are not mentioned.

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Introduction

Compatibility of herbicides and adjuvants for use on Oklahoma highway rights-of-way continue to be evaluated. New brand name products made by traditional chemical manufacturers are continuing to be introduced into the utility /rights-of-way market. Formulations of previously patented active ingredients are being introduced (generics) by new chemical companies or formulators. While these product's active ingredients (a.i.) are known, the inert ingredients can vary widely. Due to this variability, there is the potential for generics to have incompatibility issues that have yet to be identified.

Under guidelines adopted by Oklahoma department of Transportation (ODOT) in 2005 and amended in 2007 (ODOT Approved Herbicide and Adjuvant List (AHAL) Program Criteria, September 2007) products used by the ODOT maintenance division for weed control must undergo compatibility testing to avoid the accidental creation of unusable mixtures through the undesirable reaction of herbicide and adjuvant combinations. These unfavorable combinations could result in settling, layer formation, globule formation or formation of precipitants that prevent the proper application of these mixtures to highway rights-of-way. Use of incompatible mixtures can also cause poor weed control due to incorrect application rates of herbicides to the target area. All of these undesirable incompatibility issues can also result in waste of monies designated for maintenance of Oklahoma rights-of-ways.

Research Objective

The objective of this research continues to be the evaluation of readily created herbicide/adjuvant tank mixes for visually detectable physical incompatibility using an industry standard jar test.

Four generic herbicides, one reformulated "branded" product (Garlon 4 Ultra®) and one new active ingredient (aminopyralid) were evaluated for inclusion in the 2008 AHAL for use by ODOT maintenance managers (Table 1). All herbicides were combined with liquid non-ionic surfactant and a liquid drift control product. Both products are currently on state contract and available to ODOT herbicide applicators.

Materials & Methods

Specific herbicide/adjuvant combinations depended upon recommendations from OSU publication E-958, "Suggested Maintenance Practices for Roadside Weed and Brush Problems", August 2007. Experiments were preformed twice and each experiment contained two replications of treatments.

Industry standard spray carrier rates of 30 gallons per acre were simulated in each experiment, except the Garlon 4 Ultra®/Tordon K® mixture where a 100 gallon per acre carrier rate was used. Garlon 4 Ultra® and Tordon K® are recommended as a combined brush control treatment in OSU publication E-958. Consequently they were tested

together in combination with liquid drift control and NIS (non-ionic surfactant). Clear, clean, unused 1-liter soda bottles were filled with 500 ml of deionized water. Deionized water was obtained through Oklahoma State University laboratories and is characterized by a pH of 5.1 with minimal amounts of cations and anions (see Appendix C). The lack of calcium and magnesium resulted in classification of this carrier as "soft". The appropriate herbicide amounts were added to each bottle to represent rates indicated in Table 1. Experimental conditions were maintained under reasonably controlled environmental conditions where air temperatures averaged 72.5^{o} F and deionized water temperatures averaged 72.7^{o} F. Air temperature fluctuations ranged from 70.8^{o}F to 74.0^{o}F. Deionized water temperature fluctuations ranged from 71.0^{o}F to 74.0^{o}F. Temperature readings were taken hourly throughout the course of the experiments using a mercury-in-glass thermometer (accuracy $\pm$0.2 F, precision $\pm$0.1 F).

Tank mix treatments were evaluated at three separate stages (see Appendix A) to determine if any incompatibility complexes were initiated. Once all herbicide/adjuvant components were placed in the plastic bottle, the bottle was inverted slowly 10 times to mix the components. Assessment was made immediately upon mixing. After 30 minutes the bottle was checked for any incompatibility complexes before being inverted slowly for 10 times. Upon this mixing effort, a final evaluation was performed for incompatibility. Four questions were asked at each stage of the evaluation (see Appendix B) to assess the major visual incompatibilities that are commonly found. The visual physical incompatibilities for which the herbicide/adjuvant tank mixes were assessed included: formation of precipitates, layering, change in flocculation and excessive foaming. Bottles were backlit with strong light sources to make incompatibilities more evident, if present. Digital images were recorded for all herbicide/adjuvant tank mix combinations during the third replication.

Results & Discussion

No major incompatibilities were observed in any of the six herbicide/adjuvant combinations. Results were also very consistent among replications. Very minor formation of flakes and sludges were observed in a few combinations but, these were very minor. Some formations were attributed to minimal amount of initial agitation of bottles, as called for in our protocol, when adjuvants were added. Our testing can be considered to represent a conservative approach. We are confident that this testing method would detect incompatible tank mix combinations that would be problematic to the ODOT RVM Manager. Incompatibility complexes formed were so minor that the visual ratings are not shown in this report. We do not feel that any of the herbicide/adjuvant tank mixes would cause any problems to ODOT personnel as long as labeled directions are followed and characteristics of water carrier sources are not extreme.

Summary and Recommendations

OSU RVM (Roadside Vegetation Management) Program compatibility testing of these six herbicides combined with adjuvant and drift control products available through state herbicide contract, did not detect any significant or major visibly discernable physical incompatibilities

The specific herbicide/adjuvant tank mixes, combined at the specified rates indicated in Table 1, would not be expected to create any tank mix combinations that would be unusable, nor create any hazardous waste requiring special disposal measures for ODOT pesticide applicators. Our compatibility testing is only for physical incompatibility that can be detected via a visual test. ODOT herbicide applicators are encouraged to read all herbicide labeled information concerning water carrier issues and to be familiar with the water source 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" to determine specific characteristics of water sources tested at that time. Additionally, we would encourage periodic testing of water sources especially if water sources change from previous sources.

We are formally recommending that herbicides tested in this study be included in the next ODOT Approved Herbicide & Adjuvants List (AHAL).

Table 1. Six selected herbicide/adjuvant combinations evaluated for tank mix compatibility. These treatments included NIS(1) and liquid drift control.

Herbicide Components				Adjuvant Component			
Herbicide / Source	**Herbicide active ingredient (a.i.)**	**Formulation**	**Herbicide rate**	**Adjuvant**	**Adjuvant type**	**Adjuvant concentration**	**Adjuvant distributor**
Diuron 80 WDG Weed Killer (UAP-Loveland Products, Inc.)	Diuron	80% Water Dispersible Granule	2.4 LB A/A	Detain II Red River 90	Liquid drift NIS & Aquatic NIS	12 FL OZ/100 GAL 0.25 % v/v	Estes Red River
Garlon 4 Ultra + Tordon K (Dow AgroSciences LLC)	Triclopyr + picloram	4 LB Soluble liquid 2 LB Soluble liquid	3.0 LB A/A 0.5 LB A/A	Detain II Red River 90	Liquid drift NIS & Aquatic NIS	12 FL OZ/100 GAL 0.25 % v/v	Estes Red River
Imazapyr 2SL (Vegetation Management LLC)	Imazapyr	2 LB Soluble Liquid	0.5 LB A/A	Detain II Red River 90	Liquid drift NIS & Aquatic NIS	12 FL OZ/100 GAL 0.25 % v/v	Estes Red River
Milestone VM (Dow AgroSciences LLC)	Aminopyralid	2 LB Soluble Liquid	0.0625 LB A/A	Detain II Red River 90	Liquid drift NIS & Aquatic NIS	12 FL OZ/100 GAL 0.25 % v/v	Estes Red River
MSM E-Pro 60 EG (Etigra, LLC)	Metsulfuron methyl	60% Water Dispersible Extruded Granule	0.0375 LB A/A	Detain II Red River 90	Liquid drift NIS & Aquatic NIS	12 FL OZ/100 GAL 0.25 % v/v	Estes Red River
SFM E-Pro 75 EG (Etigra, LLC)	Sulfometuron methyl	75% Water Dispersible Extruded Granule	4 OZ WT/A	Detain II Red River 90	Liquid drift NIS & Aquatic NIS	12 FL OZ/100 GAL 0.25 % v/v	Estes Red River

1.) Non-ionic surfactant

Appendix A: Procedures for Conducting Herbicide/Adjuvant Compatibility Testing

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

Mixing should occur by slowly inverting bottle 3 or 4 times after each product is added. This should be adequate to mix all liquids but dry herbicides will 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 B: Compatibility Study Data Collection Form

Herbicide Treatment:													Evaluation Step: 1st 2nd 3rd			
Evaluator:							Study/Replication Number:						Date:			
Adjuvant	Supplier	1. Were precipitates formed?					2. Were separate layers formed?			3. Did herbicide mixture flocculate?			4. Was there a change in foaming?			5. Other?
		No	flakes	colored globules	clear globules	sludges	No	suspend	settled	No	suspend	settled	No change	More	Less	
Detain II	Estes															
Red River 90	Red River															
check																

Appendix C: Deionized Water Analytical Laboratory Report

OKLAHOMA COOPERATIVE EXTENSION SERVICE

SOIL, WATER & FORAGE ANALYTICAL LABORATORY

Division of Agricultural Sciences and Natural Resources • Oklahoma State University
Plant and Soil Sciences • 045 Agricultural Hall • Stillwater, OK 74078
Email: soils_lab@mail.pss.okstate.edu
Website: www.soiltesting.okstate.edu

WATER QUALITY REPORT

DENNIS MARTIN
HORTICULTURE
ODOT Research
360 AG HALL

Name:

Location:

Lab ID No.: 472920
Customer Code: 218
Sample No.: 1
Received: 8/28/2007
Report Date: 9/5/2007

TEST RESULTS

Cations		Anions		Other	
Sodium (ppm)	2	Nitrate-N (ppm)	< 1	pH	5.1
Calcium (ppm)	0	Chloride (ppm)	1	EC (µmhos/cm)	11
Magnesium (ppm)	0	Sulfate (ppm)	1		
Potassium (ppm)	0	Boron (ppm)	0.02		
		Bicarbonate (ppm)	2		

Derived Values		Derived Values(cont'd)	
Total Soluble Salts (TSS in ppm)	7	Soduim Percentage	71.1%
Sodium Adsorption Ratio (SAR)	0.7	Hardness (ppm)	2
Potassium Adsorption Ratio (PAR)	0.0	Hardness Class	Soft
		Alkalinity (ppm as CaCO3)	2

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