2004 Report on
The Evaluation of Adjuvants and Recommended Herbicides for Tank Mix Compatibility

Project 2157: Section 2

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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 used in tank mixtures can be a concern of Oklahoma Department of Transportation (ODOT) roadside managers due to i) reduced weed control efficacy of an incompatible tank mix, ii) costs of chemical waste disposal if an incompatible mixture cannot be sprayed from a tank and iii) the inefficient use of labor hours when incompatible tank mixtures are unknowingly created.

The OSU RVM program performed drift control product compatibility testing for ODOT in 1995 (see Roadside Vegetation Management Final Report, September 1996). Several drift control products available at that time were found to have severe tank mix incompatibility. Results of incompatibility testing were implemented into ODOT vegetation management programs through continuing education workshops and publications dealing with herbicide tank mix suggestions. Research results from that earlier trial were valuable to ODOT personnel as it allowed them to avoid creating a tank mix that could not be effectively applied or one that would have been difficult to empty from the spray tank. If an incompatible tank mix were created, this may have led to the creation of a situation where hazardous waste would have been costly to remediate.

There has been no testing of herbicide/adjuvants tank mixes by our program since 1995 and no reports released by our program since 1996. Since that time, many new adjuvant products have been introduced into the roadside vegetation market and several previously untested (as yet not tested for compatibility) products are listed on the current ODOT Herbicide bid list. These products include new drift control agents, surfactants and herbicide treatment enhancers such as sprayable ammonium sulfate (AMS).

Research Objective

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

Materials & Methods

The adjuvants selected for testing were those adjuvants listed on the ODOT 2003/2004 herbicide contract along with those recently listed on past ODOT herbicide contracts. The herbicides and their use rates were those recommended by the OSU RVM program.

Six herbicides and fourteen herbicide combinations (Tables 1a, 1b, and 1c) were tested with twelve adjuvant tank mix partners to identify any incompatibilities. Specific herbicide/adjuvant combinations depended upon recommendations from OSU publication

E-958, “Suggested Maintenance Practices for Roadside Weed and Brush Problems”, November 2003 (now updated to November 2004). The experiment was preformed twice and each experiment contained two replications of treatments. This experimental design resulted in 143 herbicide/adjuvant combinations per replication within experiments.

Industry standard spray carrier rates of 30 gallons per acre were simulated in each experiment. Clear, clean, unused 1-liter soda bottles were filled with 500 ml of deionized water. The appropriate herbicide amounts were added to each bottle to represent rates indicated in Tables 1a-c. Experimental conditions were maintained under reasonably controlled environmental conditions where air temperatures averaged 71.8^{o} F and deionized water temperatures averaged 72.3^{o} F. Air temperature fluctuations ranged from 70.3^{o}F to 74.9^{o}F. Deionized water temperature fluctuations ranged from 72.0^{o}F to 73.5^{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 formed. Summarizing, 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 attempt, a final evaluation was performed for incompatibility. Four questions were asked at each stage of the evaluation (see Appendix B) so as 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 143 herbicide/adjuvant combinations. Results were also very consistent among replications. Very minor formation of flakes, globules, sludges, and layers were observed on 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. Still other very minor incompatibilities occurred due to prill size of the dry adjuvants. 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 trivial that the visual ratings are not shown in this report. We feel that none of the herbicide/adjuvant tank mixes were of an order that would present any problems to ODOT personnel in conducting their weed control programs. Certainly none of the very minor complexes that we witnessed in these experiments were anywhere near the magnitude of incompatibility found by tank mixes created using products that were on the market during the 1994-95 time period.

Summary and Recommendations

Our compatibility testing did not identify any visually detectable physical incompatibilities of concern when OSU-recommended combinations of herbicides and adjuvants were tested. The specific herbicide/adjuvant tank mixes at the specified rates indicated in Tables 1a – c would not be expected to create any tank mix combinations that would be unusable, nor create any hazardous waste requiring costly or special disposal measures for ODOT pesticide applicators. Our compatibility testing is only for physical incompatibility that can be detected via a visual test. Our physical incompatibility testing methodology does not include testing for effects on weed control efficacy.

We are formally recommending that adjuvants tested in this study be included in the next ODOT Approved Herbicide & Adjuvants List (AHAL). Furthermore, if valid compatibility data is not already available, we recommend that any new drift control products, adjuvants and new herbicides under consideration for inclusion on a future AHAL be tested for tank mix compatibility before being included on the AHAL.

Table 1a. Sixty-six selected herbicide/adjuvant combinations evaluated for tank mix compatibility. These treatments included NIS[(1)], aquatic NIS, liquid drift control, dry drift control + AMS[(2)].

Herbicide Components			Adjuvants Component				
Herbicide	**Formulation**	**Herbicide rate**	**Adjuvant**	**Adjuvant type**	**Formulation**	**Adjuvant concentration**	**Adjuvant distributor**
Atrazine	4 LB Dry Flowable	2.0 LB A/A	Surf King	NIS	Liquid	0.5 % v/v	Estes
MSMA	6 LB Soluble Liquid	3.0 LB A/A	AD-Spray 80	NIS	Liquid	0.5 % v/v	Helena
MSMA + Oust	6 LB Soluble Liquid 75 Wettable Granule	3.0 LB A/A 0.047 LB A/A	Red River 90	NIS & Aquatic NIS	Liquid	0.5 % v/v	Red River
MSMA + SFM 75	6 LB Soluble Liquid 75 Wettable Granule	3.0 LB A/A 0.047 LB A/A	Timberland 90	NIS & Aquatic NIS	Liquid	0.5 % v/v	UAP
MSMA + Outrider	6 LB Soluble Liquid 75 Wettable Granule	3.0 LB A/A 0.047 LB A/A	Induce	NIS Aquatic	Liquid	0.5 % v/v	Helena
Overdrive	70 Wettable Granular	4 OZ WT/A	Aqua King	NIS Aquatic	Liquid	0.5 % v/v	Estes
			ChemTrol	Liquid drift	Liquid	64 FL OZ/100 GAL	Helena
			Detain II	Liquid drift	Liquid	12 FL OZ/100 GAL	Estes
			Pointblank WM	Liquid drift	Liquid	4.0 FL OZ/100 GAL	Helena
			Array	Dry Drift + AMS	Granular	9 LB/100 GAL	Estes
			Dry Poly Wet	Dry Drift + AMS	Granular	9 LB/100 GAL	Red River

1.) Non-ionic surfactant
2.) Ammonium sulfate

Table 1b. Twenty-five selected herbicide/adjuvant combinations evaluated for tank mix compatibility. These treatments included liquid drift control and dry drift control agents + ammonium sulfate (AMS).

Herbicide Component			Adjuvant Component				
Herbicide	**Formulation**	**Herbicide rate**	**Adjuvant**	**Adjuvant type**	**Formulation**	**Adjuvant concentration**	**Adjuvant distributor**
Roundup Pro Concentrate	5 LB Soluble liquid	0.5 LB A/A	Detain II	Liquid drift	Liquid	12 FL OZ/100 GAL	Estes
Mirage	4 LB Soluble Liquid	0.5 LB A/A	ChemTrol	Liquid drift	Liquid	64 FL OZ/100 GAL	Helena
Honcho Plus	4 LB Soluble Liquid	0.5 LB A/A	Pointblank WM	Liquid drift	Liquid	4.0 FL OZ/100 GAL	Helena
Campaign + AMS	3.1 LB Soluble Liquid 99% Sprayable Grade	32 FL OZ/A 17 LB/100 GAL	Array	Dry Drift + AMS	Granular	9 LB/100 GAL	Estes
Campaign + AMS + Overdrive	3.1 LB Soluble Liquid 99% Sprayable Grade 70 Wettable Granule	32 FL OZ/A 17 LB/100 GAL 2.0 WT/A	Dry Poly Wet	Dry Drift + AMS	Granular	9 LB/100 GAL	Red River

Table 1c. Twenty-seven selected herbicide/adjuvant combinations evaluated for tank mix compatibility. These treatments included liquid drift control agents.

Herbicide Component			Adjuvant Component				
Herbicide	**Formulation**	**Herbicide rate**	**Adjuvant**	**Adjuvant type**	**Formulation**	**Adjuvant concentration**	**Adjuvant distributor**
Roundup Pro Concentrate + Oust	5 LB Soluble Liquid 75 Wettable Granule	0.5 LB A/A 0.047 LB A/A	Detain II	Liquid drift	Liquid	12 FL OZ/100 GAL	Estes
Mirage + Oust	4 LB Soluble Liquid 75 Wettable Granule	0.5 LB A/A 0.047 LB A/A	ChemTrol	Liquid drift	Liquid	64 FL OZ/100 GAL	Helena
Honcho Plus + Oust	4 LB Soluble Liquid 75 Wettable Granule	0.5 LB A/A 0.047 LB A/A	Pointblank WM	Liquid drift	Liquid	4.0 FL OZ/100 GAL	Helena
Roundup Pro Concentrate + SFM 75	5 LB Soluble Liquid 75 Wettable Granule	0.5 LB A/A 0.047 LB A/A					
Mirage + SFM 75	4 LB Soluble Liquid 75 Wettable Granule	0.5 LB A/A 0.047 LB A/A					
Honcho Plus + SFM 75	4 LB Soluble Liquid 75 Wettable Granule	0.5 LB A/A 0.047 LB A/A					
Roundup Pro Concentrate + Outrider	5 LB Soluble Liquid 75 Wettable Granule	0.5 LB A/A 0.047 LB A/A					
Mirage + Outrider	4 LB Soluble Liquid 75 Wettable Granule	0.5 LB A/A 0.047 LB A/A					
Honcho Plus + Outrider	4 LB Soluble Liquid 75 Wettable Granule	0.5 LB A/A 0.047 LB A/A					

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	
Surf King	Estes															
Aqua King	Estes															
Detain II	Estes															
Array	Estes															
Red River 90	Red River															
Dry Poly Wet	Red River															
Timberland 90	UAP															
ChemTrol	UAP															
AD-Spray 80	Helena															
Induce	Helena															
Pointblank WM	Helena															
Stikezone PPS	Helena															
check																