# Adjuvants for Enhancing the Performance of a New Cotton Defoliant

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## Summary

Results of experiments conducted at the University of Arizona Yuma Valley Experiment Station in 1980 indicate that: (1) Thidiazuron is very responsive to effective foliar spray adjuvants; (2) significant progress in the creation of improved foliar spray adjuvants can be achieved by means of properly directed study and experimentation.

## Introduction

"DROPP" is the trade name of a promising new cotton defoliant from NOR-AM Agricultural Products, Inc. The common name of the active ingredient is thidiazuron and the chemical name is *N*-phenyl-*N*'-1, 2,3-thiadiazol-5yl urea. The common name will be used throughout this report.

Results of recent experimental investigations conducted at Yuma indicate that:

(1) There is a definite need for improved adjuvants, capable of maximizing the efficacy of chemicals applied to plant foliage.
(2) Significant progress in the creation of improved foliar spray adjuvants can be achieved by means of properly directed study and experimentation.
(3) Thidiazuron is very responsive to foliar spray adjuvants. Its performance is influenced to a considerable degree by the choice of the adjuvant with which it is applied.

In this report we briefly explain the basis of our new plan for creating improved foliar spray adjuvants and summarize the results of preliminary experimental evaluations. Thidiazuron was the phytoactive compound in all experiments.

In order for a cotton defoliant or other foliarly-applied phytoactive chemical to be fully effective, a sufficient quantity of the active ingredient must reach its specific site(s) of action, usually within individual cells. Hence, a logical function of an effective foliar spray adjuvant should be to facilitate the arrival of the active chemical at its proper destination. This usually requires penetration of each of the following: (1) the cuticular layer of the leaf; (2) the cell walls; and (3) the cell membranes.

Our first step was to study the available information regarding the chemical composition and physical properties of these structures. This information was used as a guide in selecting chemical compounds whose molecular structure and physical properties suggested that they would be worthy of experimental evaluation as principal components of effective foliar spray adjuvants.

## General Experimental Procedure

All experiments were conducted on Deltapine 70 cotton which was established in a plant two, skip two pattern, to facilitate spraying and evaluation. Each experiment consisted of ten treatments in a randomized complete block design with six replications. Each experiment included an untreated check, a "no adjuvant" check, and at least one well known standard of comparison. "Sunspray 11E," an emulsifiable non-phytotoxic petroleum oil, recommended by the supplier of thidiazuron, was the principal standard of comparison in all experiments. An emulsifiable vegetable oil adjuvant, designated "Bio-Veg," was used as a second standard of comparison. Thidiazuron was applied at a uniform rate recommended by the supplier, in each treatment except the untreated check in each experiment. The cotton defoliation treatments were applied by hand using a 3-gallon pressure tank sprayer. The spray was carefully directed to uniformly reach the upper surface of the leaves. Plot size was two rows, each 20 feet long.

The condition of the cotton plants in each plot at the time of harvest-aid chemical treatment was carefully noted and recorded. Plant responses and environmental conditions were observed and recorded throughout the period of evaluation. Evaluation was based on a visual estimate of the percent defoliation and desiccation before and after treatment. Each value was rechecked at least twice. The appropriate values were used to compute an "Efficacy Index" (E) according to the following formula:

$$E = \frac{\% \text{ after treatment} - \% \text{ before treatment}}{100 - \% \text{ before treatment}}$$

The calculated "Efficacy Index" provides an evaluation of the effect of the treatments on the foliage actually on the plants at the time of application. Calculated "Efficacy Indices" can vary between 0 and 1. A value of zero would indicate "no effect" and a value of one would be indicative of "perfection". Results of each experiment were subjected to analysis of variance and differences between values of the average "Efficacy Index" were evaluated by Duncan's Multiple Range Test.

## General Condition of the Cotton Plants at Time of Treatment

In Experiments 1 and 2, the plants were relatively short. About 10% of the foliage was recently developed. Initial defoliation varied from 5 to 15%. There was no desiccation. Insect injury to foliage was minimal. The plants were moderately lodged and plot to plot variation was relatively high.

In Experiment 3, although initial defoliation only varied from 5 to 15%, there were pronounced variations in the amount of vegetative growth. Plants in many plots were very vegetative, with dense foliage; while plants in other plots had very little foliage. There was no natural desiccation or appreciable insect injury to the foliage. Lodging was moderate to severe.

In Experiments 4 and 5, the plants were large, leafy, and badly lodged. Initial defoliation varied from 5 to 15%. Ten to 15% of the foliage was recently developed. Mite and/or insect injury varied from none to about 30% of the total leaf surface. There was little or no initial desiccation in Experiment 4, but in Experiment 5, the initial desiccation varied from 5 to 30%. Field variation was rather high in Experiment 4 but was of little concern in Experiment 5.

## Principal Cultural Data

Previous Crop: Small grains

Planting Date: 6 and 7 March 1980, in moist soil

Fertilization: Preplant - Ammonium nitrate broadcast at the rate of 50 lbs N per acre on 23 January 1980. Post emergence - Ammonium nitrate, side-dressed at the rate of 50 lbs N per acre on 25 April 1980. Ammonia, applied in the irrigation water at the rate of 75 lbs N per acre on 11 July 1980.

Herbicides: Preplant - a,a,a-trifluoro-2,6-dinitro-*N*,*N*-dipropyl-*p*-toluidine (trifluralin), sprayed over beds and furrows at the rate of 0.75 lb per acre on 3 March 1980, and promptly incorporated with the rolling cultivator.
Lay-by - 2,4-bis(isopropylamino)-6-methylthio-*s*-triazine (prometryn), applied as directed spray at the rate of 1.6 lbs per acre on 26 June 1980.

Irrigations: Preplant - 31 January 1980
Post emergence - 9 May, 13, 27 June, 11, 24 July, and 8 August 1980

## Principal Results

Thirteen new experimental adjuvants were evaluated in 1980. Their chemical and physical properties were entirely different from those of any adjuvants that we had previously investigated. Results of preliminary evaluations of these adjuvants are presented in Tables 1 to 3. One adjuvant, designated Adjuvant II, was consistently outstanding and was noticeably more effective than the recommended standard, "Sunspray 11E" in every comparison. Other experimental adjuvants performed well in some replications, but were considerably less effective in others.

Because of its consistently good performance in Experiments 1 and 3, Adjuvant II was used as a second standard of comparison in five subsequent experiments instead of "Bio-Veg," and thereby subjected to repeated replicated tests. The following additional practical advantages in the use of Adjuvant II were observed:

(1) It dispersed readily in the aqueous spray mixture to yield a good emulsion, which, when applied as a foliar spray, resulted in excellent uniform wetting of the foliage without foaming.

(2) Leaf abscission occurred at a relatively rapid rate when Adjuvant II was applied with thidiazuron.

Adjuvant II was also evaluated in binary mixtures with various representative types of commercial surfactants. It was the major component of each of these binary mixtures. Eighteen different surfactants, representing each ionogenic class, e.g., anionic, nonionic, zwitterionic, and cationic, were used as the minor component in these binary mixtures in a total of five experiments. Results of two of these experiments (4 and 5) are presented in Tables 4 and 5. Adjuvant II and "Sunspray 11E" were the standards of comparison in each of these experiments. It was clearly evident that none of these binary mixtures resulted in any improvement over Adjuvant II alone. Adjuvant II was consistently more effective than the recommended "Sunspray 11E" in all of the seven replicated experiments in which it was involved in 1980. Results of four of these comparisons are presented in Tables 1, 3, 4, and 5.

Although progress achieved in 1980 is encouraging, it should be considered only a beginning. There is much to learn and more work is needed before we can be confident that we have fulfilled our objective of creating superior adjuvant(s) capable of consistently maximizing the efficacy of chemicals applied to plant foliage. At the present time we have only one year's data on one phytoactive chemical

on a single plant species at one location. We plan to expedite progress during the winter, spring and early summer by continued study and by conducting replicated experiments on various plant species with various phytoactive chemicals.

Table 1. Calculated Defoliation Efficacy Index (Ave. of 6 reps.) with Thidiazuron and Experimental Adjuvants, Experiment 1, Yuma 1980.

| Treatment | Ave. Efficacy Index[1/] |
|---|---|
| 6. 0.10 lb/ac Thidiazuron 1%(v/v) Adjuvant II | 0.92 a |
| 10. 0.10 lb/ac Thidiazuron 1%(v/v) Adjuvant VI | 0.80 ab |
| 8. 0.10 lb/ac Thidiazuron 1%(v/v) Adjuvant IV | 0.79 b |
| 4. 0.10 lb/ac Thidiazuron 1%(v/v) "Bio-Veg" | 0.78 b |
| 3. 0.10 lb/ac Thidiazuron 1%(v/v) "Sunspray 11E" | 0.77 b |
| 7. 0.10 lb/ac Thidiazuron 1%(v/v) Adjuvant III | 0.77 b |
| 9. 0.10 lb/ac Thidiazuron 1%(v/v) Adjuvant V | 0.68 b |
| 5. 0.10 lb/ac Thidiazuron 1%(v/v) Adjuvant I | 0.54 c |
| 2. 0.10 lb/ac Thidiazuron | 0.17 d |
| 1. Untreated Check | 0.03 e |

1/ Averages followed by a common letter are not significantly different at the 5% level, according to Duncan's Multiple Range Test.

$L.S.D._{0.05}$ = 0.13 C.V. = 18.4%

Standard error = 0.047

Treatments applied on 5 September 1980 and evaluated on 19 September 1980.

Table 2. Calculated Defoliation Efficacy Index (Ave. of 6 reps.) with Thidiazuron and Experimental Adjuvants, Experiment 2, Yuma 1980.

| Treatment | Ave. Efficacy Index[1/] |
|---|---|
| 6. 0.10 lb/ac Thidiazuron 1% (v/v) Adjuvant VIII | 0.82 a |
| 5. 0.10 lb/ac Thidiazuron 1% (v/v) Adjuvant VII | 0.73 ab |
| 4. 0.10 lb/ac Thidiazuron 1% (v/v) "Bio-Veg" | 0.68 abc |
| 8. 0.10 lb/ac Thidiazuron 1% (v/v) Adjuvant X | 0.64 bc |
| 3. 0.10 lb/ac Thidiazuron 1% (v/v) "Sunspray 11E" | 0.61 bc |
| 10. 0.10 lb/ac Thidiazuron 1% (v/v) Adjuvant XII | 0.54 cd |
| 7. 0.10 lb/ac Thidiazuron 1% (v/v) Adjuvant IX | 0.43 d |
| 9. 0.10 lb/ac Thidiazuron 1% (v/v) Adjuvant XI | 0.23 e |
| 2. 0.10 lb/ac Thidiazuron | 0.17 e |
| 1. Untreated Check | 0.00 f |

1/ Averages followed by a common letter are not significantly different at the 5% level, according to Duncan's Multiple Range Test.

$L.S.D._{0.05}$ = 0.16 C.V. = 27.7%

Standard error = 0.055

Treatments applied on 5 and 6 September 1980 and evaluated 20 September 1980.

Table 3. Calculated Defoliation Efficacy Index (Ave. of 6 reps.) with Thidiazuron and Experimental Adjuvants, Experiment 3, Yuma 1980.

| Treatment | Ave. Efficacy Index[1/] | |
|---|---|---|
| 5. 0.15 lb/ac Thidiazuron 1% (v/v) Adjuvant II | 0.92 | a |
| 10. 0.15 lb/ac Thidiazuron 0.5% (v/v) Adjuvant II 0.5% (v/v) "Sunspray 11E" | 0.76 | b |
| 3. 0.15 lb/ac Thidiazuron 1% (v/v) "Sunspray 11E" | 0.71 | b |
| 4. 0.15 lb/ac Thidiazuron 1% (v/v) "Bio-Veg" | 0.66 | b |
| 8. 0.15 lb/ac Thidiazuron 1% (v/v) Adjuvant VIII | 0.65 | b |
| 6. 0.15 lb/ac Thidiazuron 1% (v/v) Adjuvant III | 0.64 | b |
| 7. 0.15 lb/ac Thidiazuron 1% (v/v) Adjuvant VII | 0.63 | b |
| 9. 0.15 lb/ac Thidiazuron 1% (v/v) Adjuvant XIII | 0.56 | c |
| 2. 0.15 lb/ac Thidiazuron | 0.29 | d |
| 1. Untreated Check | 0.06 | e |

1/ Averages followed by the same letter are not significantly different at the 5% level, according to Duncan's Multiple Range Test.

L.S.D.$_{0.05}$ = 0.15 C.V. = 21.3%

Standard error = 0.051

Treatments applied on 16 September 1980 and evaluated on 30 September 1980.

Table 4. Calculated Defoliation Efficacy Index (Ave. of 6 reps.) with Thidiazuron and Adjuvant II Alone and in Binary Mixtures, Experiment 4, Yuma 1980.

| Treatment | Ave. Efficacy Index[1/] | |
|---|---|---|
| 4. 0.15 lb/ac Thidiazuron 1% (v/v) Adjuvant II | 0.80 | a |
| 3. 0.15 lb/ac Thidiazuron 1% (v/v) "Sunspray 11E" | 0.72 | ab |
| 8. 0.15 lb/ac Thidiazuron 0.7% (v/v) Adjuvant II 0.3% (v/v) "Triton X-100"[4/] | 0.71 | ab |
| 9. 0.15 lb/ac Thidiazuron 0.7% (v/v) Adjuvant II 0.3% (v/v) "Varonic K-210"[5/] | 0.71 | ab |
| 10. 0.15 lb/ac Thidiazuron 0.7% (v/v) Adjuvant II 0.3% (v/v) "Aerosol OT (75%)"[6/] | 0.69 | ab |
| 7. 0.15 lb/ac Thidiazuron 0.7% (v/v) Adjuvant II 0.3% (v/v) "Span 20"[3/] | 0.68 | ab |
| 6. 0.15 lb/ac Thidiazuron 0.7% (v/v) Adjuvant II 0.3% (v/v) "Tween 20" | 0.66 | b |
| 5. 0.15 lb/ac Thidiazuron 0.5% (v/v) "Tween 20"[2/] | 0.54 | c |
| 2. 0.15 lb/ac Thidiazuron | 0.33 | d |
| 1. Untreated Check | 0.02 | e |

1/ Averages followed by a common letter are not significantly different at the 5% level, according to Duncan's Multiple Range Test.

2/ Polyoxyethylene (20) sorbitan monolaurate

3/ Sorbitan monolaurate

4/ An alkyl polyethoxyethanol

5/ Polyoxyethylene (10) "coco" amine

6/ Sodium pioctyl sulfosuccinate

L.S.D.$_{0.05}$ = 0.11 C.V. = 16.7%

Standard error = 0.040

Treatments applied on 22 September 1980 and evaluated on 6 October 1980.

Table 5. Calculated Defoliation Efficacy Index (Ave. of 6 reps.) with Thidiazuron and Adjuvant II Alone and in Binary Mixtures, Experiment 5, Yuma 1980.

| Treatment | Ave. Efficacy Index[1/] | | Treatment | Ave. Efficacy Index[1/] | |
|---|---|---|---|---|---|
| 4. 0.15 lb/ac Thidiazuron 1% (v/v) Adjuvant II | 0.92 | a | 9. 0.15 lb/ac Thidiazuron 0.7% (v/v) Adjuvant II 0.3% (v/v) "Variquat B-200 (60%)"[5/] | 0.73 | cd |
| 10. 0.15 lb/ac Thidiazuron 0.7% (v/v) Adjuvant II 0.3% (v/v) "Ethoduomeen T/20"[6/] | 0.82 | b | 3. 0.15 lb/ac Thidiazuron 1% (v/v) "Sunspray 11E" | 0.72 | cd |
| 7. 0.15 lb/ac Thidiazuron 0.7% (v/v) Adjuvant II 0.3% (v/v) "Ethomid O/15"[3/] | 0.79 | bc | 6. 0.15 lb/ac Thidiazuron 0.7% (v/v) Adjuvant II 0.3% (v/v) Cetyl dimethyl betaine | 0.71 | d |
| 8. 0.15 lb/ac Thidiazuron 0.7% (v/v) Adjuvant II 0.3% (v/v) "Adogen 462 (75%)"[4/] | 0.77 | bcd | 2. 0.15 lb/ac Thidiazuron | 0.54 | e |
| 5. 0.15 lb/ac Thidiazuron 0.7% (v/v) Adjuvant II 0.3% (v/v) "Aerosol OT (75%)"[2/] | 0.73 | cd | 1. Untreated Check | 0.00 | f |

1/ Averages followed by a common letter are not significantly different at the 1% level, according to Duncan's Multiple Range Test.

2/ Sodium dioctyl sulfosuccinate

3/ Polyoxyethylene (5) oleyl amide

4/ Dimethyl di "coco" ammonium chloride

5/ Benzyl dimethyl ammonium chloride

6/ N,N'-Polyoxyethylene (10)-N-"tallow"-1,3-diaminopropane

$L.S.D._{0.05}$ = 0.05 $L.S.D._{0.01}$ = 0.07 C.V. = 6.6% Standard error = 0.018

Treatments applied on 30 September 1980 and evaluated on 15 October 1980.

## COTTON HARVEST-AID CHEMICALS

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Harvest-aid chemicals prepare the plant for machine harvest and reduce leaves, trash and green stain in the lint. Since maturity of cotton fiber essentially stops after the leaves shed, timing is important. Remember, if you defoliate before the last boll you wish to harvest reaches maturity, expect some reduction in fiber strength, micronaire and yield.

In these tests, harvest-aid chemicals were applied to separate plots of the same field on October 1 when the temperature was a maximum of 106°F and minimum of 75°F. Temperatures remained continuously warm after application. The applications were made with a Hi-Boy sprayer using 5 nozzles per row at 1.5 mph. The total volume of spray was 29 gpa and the pressure was 40 psi. Plant height for the Upland cotton ranged from 44-46 inches in a population of 2-3 plants per foot or about 30,000 plants per acre.

Results of potential harvest-aid chemicals are presented in Table 1.