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GLYPHOMAX WITH VARIOUS ADJUVANTS OVER-THE-TOP IN ROUNDUP READY COTTON: CROP SAFETY AND YIELD

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Abstract

To determine the safety to cotton of various adjuvants tank mixed with Glyphomax herbicide, which requires such adjuvants, field trials were conducted at eight locations across the Cotton Belt. Varieties used included PM1218BR, ST4892BR, SG501BR and PM2280BR, all glyphosate tolerant varieties. Best production and pest management practices were employed. Treatments focused on the type and amount of recommended adjuvants used in tank mixture with Glyphomax herbicide (4 lbs. isopropylamine salt of glyphosate / gallon). Each treatment included two applications of a glyphosate/adjuvant mixture over-the-top (OTT) before the cotton 5th leaf stage and 1-2 post-directed applications between the 5th and 9th leaf stages. Glyphomax was applied at 1 quart / acre in tank mix combinations of nonionic surfactants and water conditioners. Adjuvants used included LI-700, Choice, Optima, AG-98, R-11, Surf Aid, Induce, X-77, Activator 90, ammonium sulfate and Quest. The adjuvants were tested at their recommended label rate, and at 2X this rate. One treatment included an off-label, over-the-top late application at the 8-9 LF stage of cotton. Cotton safety from the comparison treatments Glyphomax Plus and Roundup Ultra was excellent, and mean peak injury across locations was 2% and 3% for the two treatments, respectively. Glyphomax herbicide tank mixed with LI-700 and Choice showed excellent visual crop safety. The adjuvants Optima and AG-98 caused transient injury greater than the comparison treatments at 1-2 locations. However, no adjuvant at its label rate in tank mixture with Glyphomax reduced seed cotton yield compared to Glyphomax Plus or Roundup Ultra at any location. Glyphomax Plus and Roundup Ultra were not significantly different from each other in yield at any location, with mean seed cotton yields across locations of 2817 and 2799 lbs. / acre, respectively. In contrast, a late, off-label glyphosate application at the 8-9 cotton LF stage showed significantly reduced yield at 6 of 10 locations. There was no evidence to suggest that the adjuvants tested cannot be used safely in RR cotton at their label rates. Moreover, late application of glyphosate was clearly much more risky to RR cotton yield than misapplication of nonionic surfactants or water conditioners.

Introduction

Roundup Ready™ cotton is used on a large and expanding percentage of the cotton acreage in the U.S. Previous research has suggested that there is no difference in RR cotton yield between conventional weed control and control with glyphosate, so long as the herbicides are properly applied. Various formulations of glyphosate are labeled for use over the top of RR cotton. Some contain adjuvants (surfactants and other water conditioners) in the can, while others do not. Many glyphosate formulations requiring such adjuvants have been used widely on a commercial basis, and are recommended by local state extension agencies. While commercial experience has suggested that certain glyphosate formulations can be used safely in RR cotton, little research has been published examining RR cotton safety of nonionic surfactants and water conditioners applied in tank mixture with them. This research was conducted to determine the safety to cotton of one such glyphosate formulation, Glyphomax* herbicide, when used with various recommended adjuvants.

Materials and Methods

Eight field trials were conducted in 2001 across the cotton belt at locations in TX, LA, AR (2), MO, TN, MS and GA. Cotton varieties used contained the RR and Bollgard™ genes, and included PM1218BR, ST4892BR, SG501BR and PM2280BR, chosen for their suitability to the local region. Planting was between April 22 and May 29, 2001. Best production and pest management practices were employed. Irrigation was available at all but one location. Plot size was 180 to 640 $ft.^2$ with 3-4 replications.

Treatments focused on the type and amount of recommended adjuvants used in tank mixture with Glyphomax herbicide (4 lbs. isopropylamine salt of glyphosate / gallon). Each treatment included two applications of a glyphosate/adjuvant mixture over-the-top (OTT) before the cotton 5^{th} leaf stage and 1-2 post-directed applications between the 5^{th} and 9^{th} leaf stages (Figure 1). Glyphomax was applied at 1 quart / acre per application.

Chemicals used are shown in Table 1. Glyphomax was applied in tank mix combinations of nonionic surfactants and water conditioners in 10-20 gallons/acre spray volume. The adjuvants were tested at their recommended label rate, and at 2X this rate, to determine the margin of error for these adjuvant tank mixtures. For comparison, Glyphomax Plus and Roundup Ultra, neither of which requires additional surfactant, were used. One treatment included an off-label, over-the-top late application at the 8-9 LF stage of cotton (Table 2), to compare the effect of late application to the effect of misapplication of adjuvants. Not all treatments were included at all locations.

Weekly percent visual crop injury ratings were made after each application, and/or where visual change in cotton appearance from previous observations was noted. After defoliation, cotton was harvested at maturity and seed cotton yield was measured, and lint quality was measured at the Texas and St. Joseph, LA locations. Lint yield can be roughly estimated from seed cotton yield by multiplying the latter by 1/3. Yield data was not available from one location at the time this manuscript was prepared.

Visual crop injury and yield data was analyzed by ANOVA for each trial. Where significant differences were detected ($p< 0.05$), means were compared by the LSD test at the 5% level. Significant differences from the comparison standards (Glyphomax Plus and Roundup Ultra) were noted.

Results and Discussion

Weed control was excellent in all treatments, and was not a factor in cotton growth or yield in these trials. Moreover, other pests and cotton stresses were generally minimal, and cotton growth and yield was very good overall, except in one trial where irrigation was unavailable.

Cotton safety from the comparison treatments Glyphomax Plus and Roundup Ultra (Trts. 8 & 9) was excellent, and did not exceed 5% visual injury in most trials. Mean peak injury across locations was 2% and 3% for the two treatments, respectively (Figure 2). Similarly, Glyphomax tank mixed with LI-700 + Choice or Glyphomax mixed with various other nonionic surfactants shown in Table 1 had peak injury of no more than 5-10% in most cases. Injury symptoms included leaf discoloration and spotting, and were transient, usually lasting less than one week. Treatment 7, Glyphomax Plus in an off-label nonionic surfactant tank mix, also showed no significant visual injury.

A few treatments showed somewhat higher transient visual injury. The mixture of Glyphomax with Optima at the X rate showed injury significantly greater than the comparison treatments in MO and AR at one observation timing. However, in each case, this visual injury was greatly reduced within a few days time. AG-98 also showed such transient injury at one location. Other adjuvants used did not show significant cotton safety differences from the comparison treatments (data not shown).

Cotton yield results are presented in Figure 3. Mean seed cotton yield across trials was between 2641 and 2817 lbs. seed cotton / acre, except for the treatment including late OTT glyphosate application. The comparison treatments Glyphomax Plus and Roundup Ultra were not significantly different from each other in yield at any location, with mean yields across locations of 2817 and 2799 lbs. / acre, respectively. Only one treatment, Treatment 5, showed significantly reduced yield compared to the comparison treatments, which occurred at the MS and MO locations only. This was an off-label application of the 2X rate of Optima with combined with Glyphomax (Treatment 5). In contrast, the label rate of Optima did not yield differently from the comparison treatments at any location. No other combination of Glyphomax with any adjuvant mixture, including 2X applications, showed reduced yield compared to Glyphomax Plus and Roundup Ultra. Moreover, no lint quality differences were detected among any treatments at either location where it was evaluated. From this, we concluded that the products tested here could be safely used across environments in tank mix with Glyphomax herbicide by following label directions.

The off label application of Glyphomax Plus tank mixed with a nonionic surfactant did not show a yield difference from the either Glyphomax Plus alone or Roundup Ultra at any location (not shown in Figure 3). Mean yield was 2670 lbs. / acre.

In contrast, Treatment 10, which included a late, off-label application at the 8-9 cotton LF stage in addition to the other applications received by all other treatments, showed significantly reduced yield at 6 of 10 locations. This has been reported previously in RR cotton by many researchers. Across trials, mean yield for this treatment was just 2108 lbs. / acre compared to more than 2600 lbs. / acre for all other treatments (Figure 3). Therefore, late application of glyphosate was clearly much more risky to RR cotton yield than misapplication of nonionic surfactants or water conditioners. This was a favorable result for cotton growers who choose to add their own adjuvant combinations in RR cotton for optimal weed control with Glyphomax herbicide.

Note: Always follow label instructions for all agrochemical products. Neither the authors nor Dow AgroSciences LLC recommends the use of off-label applications. The off-label applications described here were conducted in controlled conditions in order to demonstrate the potential for cotton injury under such conditions.

References

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Table 1. Chemicals used.

	Product Name		
Product type	**Included in all trials**	**Included in one or more trials**	**X Rate[4]**
Glyphosate formulations[1]	Glyphomax[2]		1 quart / acre
	Glyphomax Plus[3]		1 quart / acre
	Roundup Ultra[3]		1 quart / acre
Nonionic surfactants	LI-700		1 quart / 100 gallons
	Optima		2 quarts / 100 gallons
		R-11	
		Ag-98	1 quart / 100 gallons
		Surf Aid	1 quart / 100 gallons
		Induce	1 quart / 100 gallons
		X-77	1-2 quarts / 100 gallons
		Activator 90	1 quart / 100 gallons
Water conditioners	Choice		1.5 quarts / 100 gallons
		Ammonium sulfate	8.5 to 17 lbs. / 100 gallons
		Quest	1.5 quarts / 100 gallons

[1] All three are liquid formulations containing 4 lbs. isopropylamine salt of glyphosate / gallon.
[2] Requires ionic surfactant.
[3] Does not require or allow nonionic surfactant.
[4] Rates were based on manufacturers' recommendations. Treatments receiving 2X rates (see Table 2) received double the rate shown at each application timing.

Table 2. Treatments used.

	Treatment Name	Adjuvants at X Rate	Adjuvants at 2X Rate (off-label treatment)[4]
1-2	Glyphomax LI-700 Choice	**X**	**X**
3-4	Glyphomax Optima	**X**	**X**
5-6	Glyphomax Other nonionic surfactant[1] Other water conditioner[1]	**X**	**X**
7	Glyphomax Plus Other nonionic surfactant[1,2]	**X**	
8	Glyphomax Plus		
9	Roundup Ultra		
10	Glyphomax Plus[3]		

[1] Chosen from the list of products in Table 1 based on local use patterns for the trial location.
[2] Off-label (nonionic surfactant not required or allowed with Glyphomax Plus).
[3] Same application timings as all other treatments, but received an additional, off label application, over-the top of 8-9 LF RR cotton. The label allows application only until the 5th leaf is emerging.
[4] Glyphosate was always applied at the X rate, even when adjuvant rates were doubled.

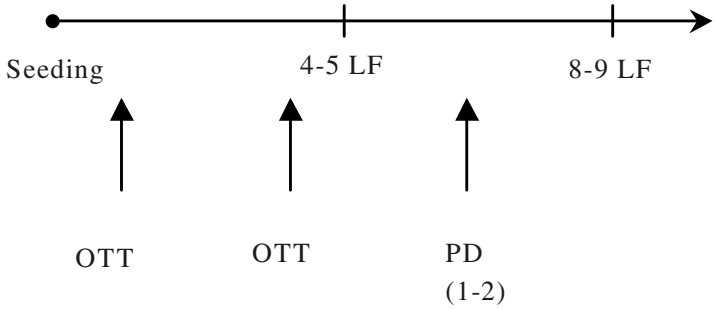

Figure 1. Arrows indicate application timings used for each treatment in the ten trials. Each treatment received 3-4 applications of glyphosate with or without specified adjuvants. Two treatments were over-the-top (OTT) of RR cotton and 1-2 treatments (as needed for weed control) were post-directed (PD) between the 5 and 9 LF stages. However, one treatment (Trt. 10) included an off-label, late over-the-top application (not shown) as a comparison.

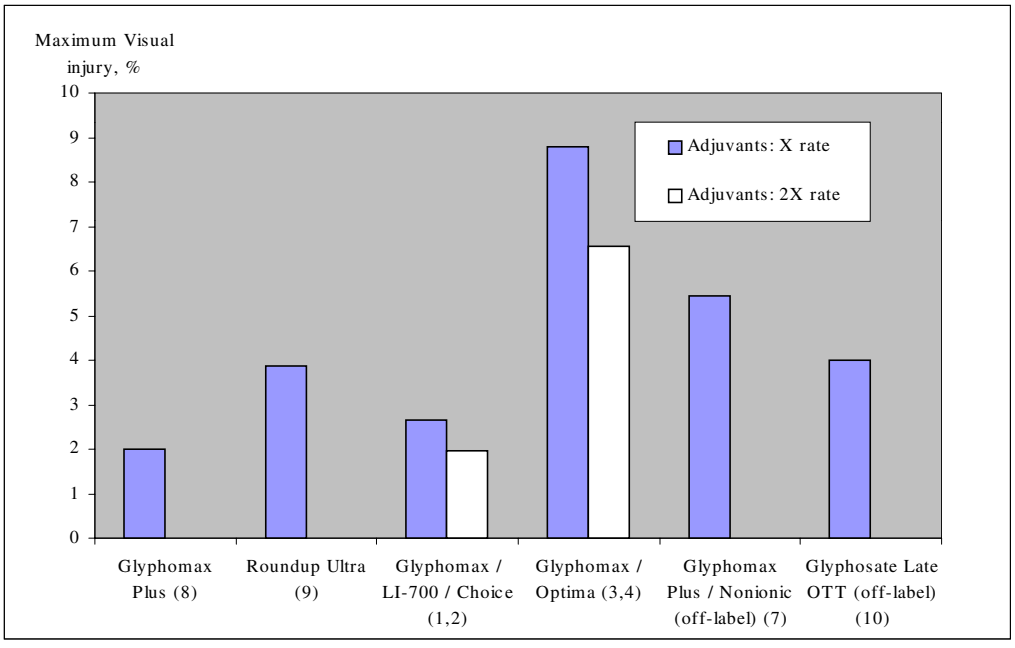

Figure 2. Maximum visual percent cotton injury across trials. Columns show means of 7-8 locations. Numbers in parentheses are treatment numbers explained in Table 2.

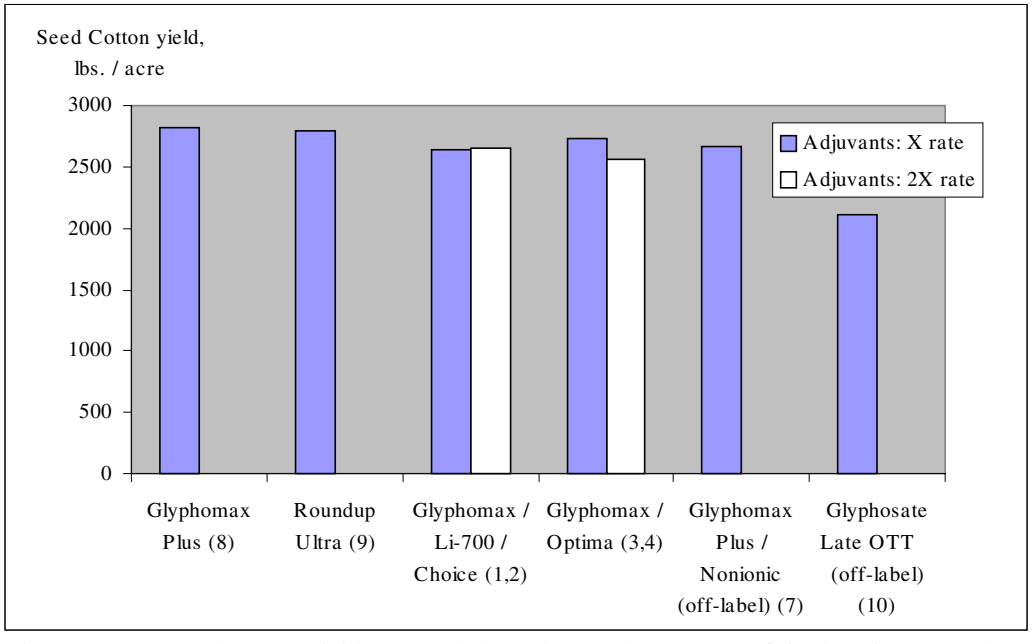

Figure 3. Mean seed cotton yield across trials. Columns show means of 6-7 locations. Numbers in parentheses are treatment numbers explained in Table 2.