SEEDLING VIGOR EFFECTS ON TOLERANCE OF ROUNDUP READY® COTTON VARIETIES TO ROUNDUP ULTRA™ HERBICIDE

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Abstract

The metabolism of glyphosate (N-phosphonomethylglycine), the active ingredient in Roundup Ultra, in Roundup Ready cotton is minimal, therefore, reproductive tolerance requires that glyphosate concentration be reduced below threshold levels primarily by growth dilution. A natural question is if seed lots vary in seed vigor, could this result in lower seed quality lots requiring more time to dilute glyphosate and perhaps result in decreased yield contribution from early fruiting positions. A two year study was conducted at Scott, MS and Hartsville, SC in 1998 and 1999 with high and low vigor index seed lots of DP 458 B/RR and DP 655 B/RR. These two varieties were selected based upon the a reputation of DP 458 B/RR a small seeded variety having a low natural vigor and DP 655 B/RR a larger seeded variety with a reputation for high vigor. The two qualities and two varieties were each treated with 0, or 0.75 LB AE/A (1.0 qt/A) Roundup Ultra applied sequentially over the top at the one and four node stage and sequentially 10 and 20 days after the four node application. The post-direct applications were not according to the label, but directed on the bottom one-third of the plant in a manner to create high levels of glyphosate in plants. Plant stand, late bloom height, nodes, NAWF, and retention of the bottom five FP-1 retention, end-of-season box map data to partition yield according to plant position, and machine harvested yield were taken for all plots. In 1998 five lots were blended to create a single lot for test purposes. In 1999, a single lot each with high and low seed vigor index was used. In 1998 high and low quality lots averaged 148 and 130 seed vigor index for DP 458 B/RR and 110 and 97 for DP 655 B/RR, respectively. In 1999 high and low quality lots averaged 150 and 98 seed vigor index for DP 458 B/RR and 167 and 106 for DP 655 B/RR, respectively. In 1998 the "high quality seed vigor index" lot for DP 655 B/RR would not have met minimal industry standards while the "low quality seed vigor index" lots for all varieties and years were well below industry standards. Due to favorable weather following all planting dates (minimum of 31 DD_{60} for the 5 days following planting at the "coldest" location), plant stands were equivalent for all seed lots. There were no substantial differences between seed vigor treatments, glyphosate application, or varieties on plant development. Box map data indicated yield accumulation by node was affected by out-of-label application of glyphosate. This resulted in a yield decrease for the aggressive and out-of-label applications of glyphosate and a one node shift in maturity.

Introduction

Roundup Ready cotton has a high level of tolerance to glyphosate (N-phosphonomethylglycine) vegetative tissue (Monsanto and Delta and Pine Land Companies, 1999). However, high glyphosate concentrations in the plant at the time of reproductive growth can result in floral damage to glyphosate. The label is written to provide a margin of safety by allowing for growth dilution of glyphosate prior to reproductive growth. An appropriate research question was could lower vigor index seed lots be more susceptible to glyphosate. Results reported by McCarty et al. (2001) at this same conference indicated no difference in growth rate through the season for high and low vigor index seed evaluated at five locations in 2000. This study directly contrasted no treatment versus aggressive and out-of-label Roundup Ultra applications to seed lots with low and high seed vigor index using two varieties grown in a total of four environments.

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Method and Materials

Two cotton varieties, Deltapine DP 458 B/RR and Deltapine DP 655 B/RR, each with seed lots of high and low seed vigor index were evaluated in the field during 1998 and 1999. These two varieties were selected based upon the a reputation of DP 458 B/RR a small seeded variety having a low natural vigor and DP 655 B/RR a larger seeded variety with a reputation for high vigor. In 1998 the high and low vigor lots were a composite sample from five lots while in 1999 they were from a single seed lot. Seed quality characteristics are summarized in Table 1. All locations and years used a 2 x 2 x 2 factorial (variety, seed vigor index, and +/- aggressive glyphosate) with four replications. Individual plots were four rows wide and 30 to 60 feet long, depending upon test location. A seeding rate representative of the area was used for all treatments at each location.

In order to detect any potential difference between quality of seed tolerance to Roundup Ultra, plots were treated sequentially and aggressively. Treated plots had four sequential applications of 0.75 LB AE/A (1.0 qt/A) Roundup Ultra applied over the top at the one and four node stage and sequentially at 10 and 20 days after the four node application. The post-direct applications were not according to the label, but directed on the bottom one-third of the plant in a manner to create high levels of glyphosate in plants.

Plant stand counts were taken from 10-ft row segment from each of the center two rows before first application of Roundup. A late bloom plant mapping was also conducted on each treatment two weeks after the final application of Roundup to determine bottom five FP-1 retention. At the end of the season plants from 10 feet in 1998 and 5 feet in 1999 feet from each of the center two rows were carefully removed and yield partitioned by node and fruiting branch position using a box map. Plots were managed for optimum yield and then spindled picked to determine yield.

Results and Discussion

Emergence

While the seed vigor index between the high vigor index seed lots averaged 144 over years and varieties compared to 108 for low seed vigor index, this difference did not result in differences in plant stand. Due to favorable weather following all planting dates (minimum of 31 DD_{60} for the 5 days following planting at the "coldest" location), plant stands were equivalent for all seed lots. Even though the Scott, MS location was planted in April, in 1999, the plantings were followed by excellent weather. Kerby et al., (1989) demonstrated a relationship between DD_{60} accumulation after planting and seed quality on the percentage of seedlings that emerge. In the California study when 25 DD_{60} were accumulated in the five days following planting, seed with a seed vigor index of 110 had as many seedlings emergence as lots with a seed vigor index of 175. Thus, in the studies reported herein, plant stands were equivalent eliminating any potential confounding effect of altered yield due to a poor plant stand.

Growth & Development

There were no interactions between seed vigor index, variety, or glyphosate treatment for any of the variables measured with late bloom plant maps (Table 2). Varieties differed in plant height and NAWF. Seed quality had a significant difference of 0.5 total nodes and a difference of 0.3 NAWF. While small, it was statistically significant. This trend was not supported in the final box map data where it was shown that 95 percent of the yield was accumulated by both seed qualities at node 17.5. This small difference in nodes also is not supported by data collected multiple times during the

season at five locations where high and low seed vigor index resulted in equivalent node development through the season (McCarty et al., 2001).

Box Mapping and Yield

To facilitate illustrations, lint yield by position was combined according to age equivalent of the first position boll. That is, yield from node 10 position 1 was combined with node 8 position 2 and node 6 position 3 as these are all comparable ages. Also, from the box mapping we were able to calculate node of the 95% zone. This is the number of nodes it takes to accumulation 95% of total yield on fruiting branches (yield from vegetative branches not included).

Yield accumulation by node was affected by the aggressive and out-of-label misapplication of glyphosate (Figure 1.) The decreased yield accumulation in lower nodes was not fully compensated for in upper nodes resulting in a yield loss (Table 3). Compensation is frequently possible (Ungar et al., 1987), but requires environmental conditions later in the season that support sustained boll set and development. The late season conditions of both 1998 and 1999 in the locations of these studies were not favorable for late season boll development. The aggressive out-of-label treatments of glyphosate in these trials shifted the maturity of the crop by one node which was a statistically significant delay (Table 3). The decrease in yield accumulation by the lower nodes for treatment was not detected in the late bloom plant maps. The late bloom map counts presence or absence of a boll. It is possible bolls were present, but were small and made less contribution to yield from lower nodes than the unsprayed plots.

Yield (Table 3), node for accumulation of 95 % of fruiting branch yield (Table 3), nor rate of yield accumulation (Figure 2) were affected by seed lot vigor index.

Summary

An effort was made in this study to aggressively apply Roundup Ultra in ways designed to cause a disruption of yield accumulation from the lower portion of the plant to determine if low vigor index seed lots would be more susceptible to injury. Yield reduction and delay in maturity was caused by the treatment. A small seeded variety with a reputation for low natural vigor (DP 458 B/RR) and a larger seeded variety with a reputation for high vigor (DP 655 B/RR) each with low and high vigor index seed lots did not respond differently to the aggressive and out-of-label glyphosate treatments. Additionally, plant stands were adequate, and both low and high vigor index seed lots produced comparable growth and equivalent yields.

References Cites

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Table 1. Selected seed lots germination results for each year of the two year study as influenced by variety and quality of seed.

Treatment						
Year	Variety	Quality	4 Day Germ	Standard Germ	Cool Germ	Seed Vigor Index
1998	DP 458 B/RR	High	83%	92%	65%	148
1998	DP 458 B/RR	Low	83%	95%	47%	130
1998	DP 655 B/RR	High	44%	84%	66%	110
1998	DP 655 B/RR	Low	46%	84%	51%	97
1999	DP 458 B/RR	High	80%	88%	70%	150
1999	DP 458 B/RR	Low	61%	84%	37%	98
1999	DP 655 B/RR	High	84%	89%	83%	167
1999	DP 655 B/RR	Low	66%	83%	40%	106

Table 2. Effect of variety, seed vigor index, and aggressive out-of-label Roundup Ultra treatments on late season plant map parameters.

			Plant Map Data				
Variety	Quality	Trt.	Bottom 5 FP1[1]	Height	Total Nodes	Veg. Nodes	NAWF
			(%)	(in)	(#)	(#)	(#)
DP 458 B/RR	High	Trt.	70.71	32.26	18.0	5.2	6.1
DP 458 B/RR	High	Untrt.	74.83	34.75	18.7	4.9	6.2
DP 458 B/RR	Low	Trt.	66.75	30.57	17.7	5.1	5.5
DP 458 B/RR	Low	Untrt.	73.50	30.77	17.7	4.9	5.6
DP 655 B/RR	High	Trt.	70.25	33.13	18.1	5.1	5.6
DP 655 B/RR	High	Untrt.	72.50	34.25	18.3	5.0	5.7
DP 655 B/RR	Low	Trt.	69.25	34.93	17.9	5.1	5.7
DP 655 B/RR	Low	Untrt.	70.67	35.27	18.1	5.0	5.6
Overall Average			71.06	33.24	18.1	5.0	5.7
Variety							
DP 458 B/RR			71.45	32.09	18.0	5.0	5.8
DP 655 B/RR			70.67	34.39	18.1	5.0	5.7
P			0.6885	0.0106	0.8305	0.9078	0.0394
Avg. Std. Error			1.3765	0.6189	0.1155	0.0513	0.0608
LSD 0.05			NA	1.24	NA	NA	0.1
Quality							
High			72.07	33.60	18.3	5.0	5.9
Low			70.04	32.88	17.8	5.0	5.6
P			0.2988	0.4176	0.0119	0.9100	0.0006
Avg. Std. Error			1.3765	0.6189	0.1155	0.0513	0.0608
LSD 0.05			NA	NA	0.2	NA	0.1
Trt.							
Treated			69.24	32.72	17.9	5.1	5.7
Untreated			72.88	33.76	18.2	4.9	5.8
P			0.0654	0.2393	0.1002	0.0141	0.4241
Avg. Std. Error			1.3765	0.6189	0.1155	0.0513	0.0608
LSD 0.05			NA	NA	NA	0.1	NA
Quality*Trt.							
High Treated			70.48	32.69	18.0	5.1	5.8
High Untreated			73.67	34.50	18.5	4.9	6.0
Low Treated			68.00	32.75	17.8	5.1	5.6
Low Untreated			72.08	33.02	17.9	4.9	5.6
P			0.8182	0.3830	0.2834	0.91	0.6093
Avg. Std. Error			1.9381	0.8452	0.1634	0.0725	0.0859
LSD 0.05			NA	NA	NA	NA	NA
Variety*Quality*Trt							
P			0.6573	0.6679	0.2948	0.6483	0.8316
Avg. Std. Error			2.7406	1.2376	0.2310	0.1025	0.1215
LSD 0.05			NA	NA	NA	NA	NA

[1]Percentage of first position fruit retained on the bottom five fruiting branches.

Table 3. Effect of variety, seed vigor index, and aggressive out-of-label Roundup Ultra treatments node for yield accumulation, and yield.

Variety	Quality	Trt.	#N95[1] (#)	Yield (LB/A)
DP 458 B/RR	High	Trt.	17.60	881
DP 458 B/RR	High	Untrt.	16.99	1034
DP 458 B/RR	Low	Trt.	17.6	922
DP 458 B/RR	Low	Untrt.	16.8	969
DP 655 B/RR	High	Trt.	18.5	814
DP 655 B/RR	High	Untrt.	16.9	963
DP 655 B/RR	Low	Trt.	18.2	811
DP 655 B/RR	Low	Untrt.	17.2	965
Overall Average			17.5	920
Variety				
DP 458 B/RR			17.2	952
DP 655 B/RR			17.7	888
P			0.0278	0.0158
Avg. Std. Error			0.1414	18.1846
LSD 0.05			0.3	36
Quality				
High			17.5	923
Low			17.5	917
P			0.8940	0.8065
Avg. Std. Error			0.1414	18.1846
LSD 0.05			NA	NA
Trt.				
Treated			18.0	857
Untreated			17.0	983
P			<0.0001	<0.0001
Avg. Std. Error			0.1414	18.1846
LSD 0.05			0.3	36
Quality*Trt.				
High Treated			18.0	847
High Untreated			16.9	999
Low Treated			17.9	867
Low Untreated			17.0	967
P			0.6199	0.3184
Avg. Std. Error			0.1999	25.7168
LSD 0.05			NA	NA
Variety*Quality*Trt.				
P			0.3234	0.2847
Avg. Std. Error			0.2827	36.3691
LSD 0.05			NA	NA

[1]Total number of nodes accounting for 95% of the harvestable yield.

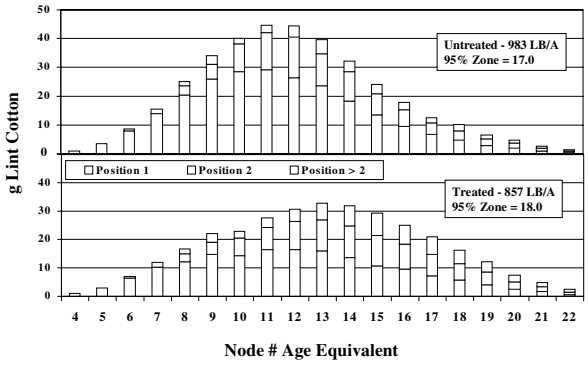

Figure 1. Treated and untreated lint yield accumulation as influenced by Roundup Ultra applied sequentially and aggressively at 1.1 nodes over the top, 4.3 nodes over the top, 7.4 nodes post-direct, and 9.9 nodes post-direct. The two post-direct applications were not applies according to the label. The sprays were directed to one-third of the plant height to increase contact and potential for injury. All applications were applied at the same rate of 0.75 LB AE/A (1.0 qt/A).

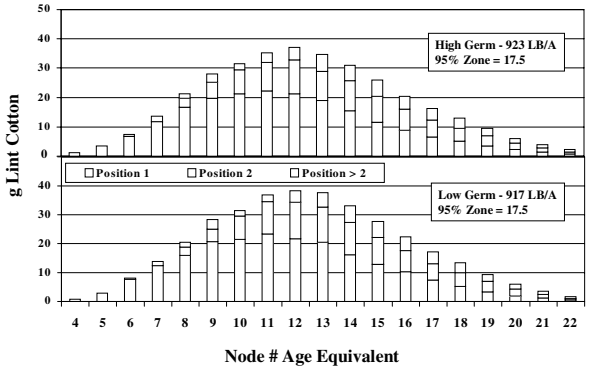

Figure 2. High germ and low germ lint yield accumulation as influenced by quality of seed.