APPLICATION OF SUB-LETHAL RATES OF GLYPHOSATE TO CONTROL REGROWTH IN COTTON: SUMMARY OF THREE YEARS RESEARCH

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Abstract

The banning of the use of arsenic acid to quickly desiccate regrowth prior to harvest has influenced researchers to investigate alternative methods for suppressing regrowth in cotton. Treatments aimed at inhibiting root growth as the boll load matures may help to suppress regrowth in cotton plants. The herbicide glyphosate is readily absorbed by the foliage and is efficiently translocated to actively growing tissues of the plant. Glyphosate may be an effective chemical to hamper new root growth thus leading to the inhibition of top regrowth. This series of studies proposes the use of sub-lethal rates of glyphosate to control regrowth in cotton. Specific objectives of the study were; (1) to determine the effect of time and (2) rate of application on growth parameters, lint yield, fiber quality and planting seed quality. Experiments were conducted at Corpus Christi, Texas during 1993, 1994 and 1995. Source of glyphosate for the study was Roundup (RU) which contains 41% of active ingredient. The applications of RU were made at various stages of crop maturity, prior to final defoliation. Conclusions and recommendations are as follows; (1) the application of sub-lethal rates of glyphosate is an effective means of controlling regrowth in cotton, (2) rate of application has a direct effect on level of regrowth inhibition, (3) applications made at less that 20% maturity (open boll) can reduce yield and micronaire, (4) applications made after 50 to 60% maturity are not as effective in controlling regrowth as applications made at 20 to 50% maturity, (5) sub-lethal rates of glyphosate can enhance defoliation efficiency and (6) the use of glyphosate as a harvest-aid chemical severely affects seed vigor. Recommendations for use of this technique are: (1) apply 12 to 16 oz. RU acre^{-1} at 30 to 50% open boll stage to inhibit regrowth, (2) as the time of application approaches 50% maturity, increase the rate of RU to 14-16 oz. acre^{-1}, (3) increase the rate to 14 to 16 oz. acre^{-1} for rank cotton or for years with high soil moisture at harvest, (4) delay the time of application and/or use a lower rate if growing conditions are conducive to low micronaire, and (5) do not use this technique if you plan to save the seed for planting purposes.

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Introduction

An important fraction of the cotton acreage produced in the Lower Coastal Bend Region of Texas (LCBR) is harvested with strippers. The acreage harvested with strippers increases in dry years because of the short plant height induced by water stress. Stripping requires the elimination of regrowth to reducer fiber staining, trash content and to eliminate hear accumulation in cotton modules. Until recently, producers of the LCBR used arsenic acid to quickly desiccate plant prior to harvest. The banning of the use of arsenic acid to quickly desiccate regrowth prior to harvest has influenced researchers to investigate alternative methods for suppressing regrowth in cotton. Regrowth in cotton is initiated as a result of relaxing carbohydrate stresses caused by the maturation of the boll load (Guinn, 1986). Work by Ben-Porath, (1985) showed that as the boll load matures, cotton plants produce a large amount of fine root hair mass. A review of the literature by Torey (1976) showed that in a number of plants, root tips produce cytokinins and probably gibberellins for transport to the shoot. Both cytokinins and gibberellins have been linked with the promotion of cell elongation, division, and growth of dormant buds (Van Stauden et. al., 1988 and Brock and Kaufman, 1991).

Treatments aimed at inhibiting root growth as the boll load matures may help to suppress regrowth in cotton plants. This hypothesis was first proposed by Guinn (1969). He showed that root starvation, induced by removing a band of phloem tissue from the stem above the soil line, was effective in controlling regrowth. Guinn suggested that a flame cultivator may be used to kill the phloem tissue. Duke (1988) showed that the herbicide glyphosate is readily absorbed by the foliage and is efficiently translocated to actively growing tissues of the plant where it accumulates. Thus, it will affect growing roots, as well as aerial growing points of the plant. Glyphosate may be an effective chemical to hamper new root growth thus leading to the inhibition of top regrowth. Cathey and Barry applied glyphosate at a rate of 1.12, 2.24, and 3.36 kg ha^{-1} at 75% open boll stage and were successful in inhibiting regrowth without affecting lint yield or fiber quality but reduced seed size and vigor.

This series of studies proposes the use of sub-lethal rates of glyphosate to control regrowth in cotton. Specific objectives were; (1) to determine the effect of time and (2) rate of application on growth parameters, lint yield, fiber quality and planting seed quality.

Materials and Methods

Experiments were conducted at Corpus Christi, Texas during 1993, 1994 and 1995. All plants were planted in 38 in. rows following standard recommendations for pest control and agronomic management practices for the Lower Coastal Bend Region of Texas. Source of glyphosate

for the study was Roundup (RU), a product of Monsanto which contains 41% active ingredient.

The 1993 Study

A Randomized Complete Block (RCB) design with four replications was used in the study. RU at the rate of 0, 8, 12 and 16 oz. acre^{-1} was applied to plots planted with cultivar DP-5415. Time of applications were 10% and 60% open boll (OB) stage. Seeds produced at position one of reproductive branches 3, 6 and 9 were collected and used to evaluate planting seed quality in a greenhouse and a field experiment.

The 1994 Experiment

A split-plot experimental design was used, with time of application as main blocks and rates as sub-plots. The blocks were replicated four times and planted with cultivar DPL-50. Time of applications were; 25, 40, 60 and 75% OB. Rates were 0, 4, 8, and 12 oz. of RU acre^{-1}.

The 1995 Experiment

As in 1994, a split-plot experimental design was used in the syudy. However, cultivar STV-132 replaced DPL-50. Times of applications were; 25, 40, 60 and 75% OB. Rates used were 0, 8, 12 and 16 oz. of RU acre^{-1}.

Final defoliation in 1993 was accomplished by an application of 0.2 lb. of Dropp Acre^{-1} in a tank mix with 2.0 lb. acre^{-1} of Prep. In 1994 and 1995, the rate of Dropp was reduced to 0.1 lb. acre^{-1}. The defoliation chemicals were applied at 70 to 75% maturity in each year of the study

The effects of glyphosate on cotton growth, yield and quality were evaluated by collecting and analyzing the following information;

Regrowth Inhibition: Measured by collecting all new growth in a meter of row per plot. Samples were placed in a drying oven and weighted. Regrowth inhibition is expressed in the study in grams of dry weight per meter of row.

Defoliation Efficiency: Measured by collecting leaves in a meter of row per replication, remaining on the plant at 7 to 10 days after the application of the defoliants. Caution was exercised to avoid including new growth in this sampling. The samples were oven dried and weighted. Defoliation efficiency is expressed in this study in grams of leaf dry weight per meter of row.

Lint Yield: Two hand harvest samples were collected to assess the yield response of the various plots. The first harvest was done when plots were approximately 10 to 20% mature and final harvest was conducted approximately 10 days after final defoliation. Two center rows, each 25 feet in length was marked for harvest in each treatment.

Fiber Quality: Twenty-five boll samples were collected during each hand harvest for determination of boll size, gin turnout and fiber quality parameters.

Results and Discussion

A detailed description of the experiments conducted in 1993 and 1994 were presented at this conference in previous years (Landivar et al., 1994 and Locke et. al., 1995). The objective of this paper is to compile the results of three years of research and present our conclusions and recommendations on the use of glyphosate as a harvest-aid chemical to control regrowth in cotton.

Applications of sub-lethal rates of glyphosate is an effective means of controlling regrowth in cotton. This observation is supported by the data presented in Tables 1,2 and 3, for the 1993, 1994 and 1995 experiments, respectively. Although the level of regrowth was strongly influenced by the environment (year), significant levels of suppression were obtained during the three years of the study. The data presented in Tables 1-3 clearly shows that levels of regrowth inhibition are strongly influenced by rate of RU. Even though most of the rates used in the study were superior (and statistically significant) to the control, the best and most consistent results were obtained with applications of 12 oz. or RU acre^{-1}.

Tables 2 and 3 (1994 and 1995) indicate that sub-lethal rates of glyphosate may improve defoliation efficiency. The dry weight of mature leaves remaining on the plant after defoliation decreased as the rate of application increased. Significant differences in defoliation efficiency were observed in 1994 (across dates of applications) in response to rates of RU. Although in 1995 there was a consistent trend, significant differences in defoliation efficiency were only obtained with the application of 16 oz. RU acre^{-1}. The data presented in Tables 2 and 3 indicate that applications of 12 to 16 oz. RU acre^{-1} can improve defoliation in comparison to the control. However, applications of 12 oz. Acre^{-1} may result in adequate levels of defoliation, while being more cost effective than the 16 oz. RU acre^{-1} rate.

Rate of application significantly reduced lint yield and micronaire values in the 1993 experiment (Table 1). In 1993, applications of RU were made at 10% open boll. A similar reduction in lint yield was observed in 1995 to the application of 16 oz. RU acre^{-1} at 10% maturity; however, micronaire values were not affected by the treatments in 1995 (Table 3). Results from these experiments strongly suggest that applications of 12 oz. of RU acre^{-1} or more during the early stages of maturity (20% or less) should be avoided. Data presented in Tables 1-3 indicate that lint yield and micronaire values were not affected by rate of RU when the applications were made after 10% OB.

Tables 1 and 2 (1993 and 1994) indicate that delaying the time of application to 60% OB or later can reduce the

effectiveness of RU to inhibit regrowth and to enhance the defoliation of leaves. It seems that at least 7 to 10 days are needed between the applications of RU and final defoliation in order to allow time for the translocation of RU to actively growing tissues. Data collected in 1995 (Table 3) using cultivar STV-232 (a more determinate cultivar), however failed to display this trend.

Analysis of the data collected during the three years of the study suggest that applications of 12 to 16 oz. RU acre^{-1} between 30 to 50% open boll can result in significant inhibition of regrowth potential of cotton crops. These applications can be also effective in enhancing the defoliation efficiency of harvest-aid chemicals. Under the growing conditions of the Coastal Bend Region of Texas, the rate and time suggested above eliminates the risk of reducing yield or micronaire of the crop.

The application of RU to cotton plants severely affected seed vigor. Table 4 shows stand establishment data collected in a greenhouse experiment and under field conditions. Seed used for the evaluation of vigor was obtained from position one of branches three, six and nine of plants receiving 8, 12 or 16 oz. RU acre^{-1}. Emergence under greenhouse conditions were statisticaly significant only in seeds produced at branch nine. However, seedling establishment under field conditions was impaired, regardless of the location where the seed was produced or the rate of RU used. These data strongly suggest that this technique of regrowth control should not be used in fields grown for the production of planting seed.

Conclusions and Recommendations

Based on the information compiled during the three years of research discussed here and the results of trials in commercial fields conducted iin the Coastal Bend Region of Texas we conclude the following;

1. Applications of sub-lethal rates of glyphosate is an effective means of controlling regrowth in cotton.

2. Rate of application has a direct effect on level of regrowth inhibition.

3. Applications made at less that 20% maturity (open boll) can reduce yield and micronaire.

4. Applications made after 50 to 60% maturity are not as effective in controlling regrowth as applications made at 20 to 50% maturity,

5. Sub-lethal rates of glyphosate can enhance defoliation efficiency.

6. Application of glyphosate severely affects seed vigor.

Recommendations for use of this technique are:

1. Apply 12 to 16 oz RU acre^{-1} at 30 to 50% open boll stage to inhibit regrowth.

2. As the time of application approaches 50% maturity, increase the rate of RU to 14 to16 oz. acre^{-1}.

3. Increase the rate to 14 to 16 oz acre^{-1} for rank cotton or for years with high soil moisture at harvest.

4. Delay the time of application to 40 to 50% OB and/or use a lower rate (12 oz.) if growing conditions are conducive to low micronaire.

5. Do not use this technique if you plan to save the seed for planting purposes.

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Table 1. Inhibition, lint yield and micronaire as affected by time and rate of application. Corpus Christi, TX, 1993.

Time of Application	Rate of Application[1]	Regrowth[2]	Lint Yield[3]	Micronaire
	UTC	13.2a	1116a	4.46a
10% OB	8	1.0bc	1062a	4.41a
10% OB	12	0.1c	919b	4.14ab
10% OB	16	0.1c	871b	3.88b
60% OB	8	13.5a	1146a	4.4a
60% OB	12	8.0ab	1176a	4.4a
LSD (P=0.05)		7.1	118	0.41
Pr>F		0.002	0.001	0.024

*Means within a column followed by the same letter are not significantly different.
[1]oz. RU per Acre
[2]Grams of regrowth per meter (3.28 feet) of row
[3]Lbs of lint Acre^{-1}

Table 2. Inhibition, lint yield and micronaire as affected by time and rate of application. Corpus Christi, TX, 1994.

Rate of Application[1]		Regrowth[2]	Defoliation Efficiency[3]	Lint Yield[4]	Micronaire
UTC		5.33a	10.02a*	751	4.49
4		4.94ab	7.11b	739	4.54
8		4.47b	6.11b	759	4.58
12		3.01c	5.09b	756	4.51
LSD (P=0.05)		0.83	2.77	26	0.17
Pr>F		0.0001	0.005	0.454	0.7067
Time of Application	% OB	Regrowth[2]	Defoliation Efficiency[3]	Lint Yield[4]	Micronaire
July 15	25	4.18	4.79b*	743	4.58
July 19	40	4.07	5.49b	754	4.51
July 23	60	4.38	7.19b	745	4.54
July 27	75	5.11	10.86a	763	4.49
LSD (P=0.05)		0.98	2.55	26.0	0.17
Pr>F		0.2020	0.0001	0.454	0.7558

*Means within a column followed by the same letter are not significantly different.
[1]oz. RU per Acre
[2]Grams of regrowth per meter (3.28 feet) of row
[3]Grams of leaf dry weight per meter (3.28 feet) of row
[4]Lbs of lint Acre^{-1}

Table 3. Inhibition, lint yield and micronaire as affected by time and rate of application. Corpus Christi, TX, 1995.

Time of Application	Rate of Application[1]	Regrowth[2]	Defoliation Efficiency[3]	Lint Yield[4]	Micronaire
10% OB	UTC	57.2a	13.8	1052a	3.8
	8	35.7b	11.7	1025a	3.7
	12	27.6bc	10.7	1022a	3.9
	16	13.1c	6.9	928b	3.8
LSD (P=0.05)		16.0	6.5	82	0.25
P>F		0.0001	0.1926	0.0244	0.4946
30% OB	UTC	50.8a	7.8	955	3.8
	8	23.6b	8.8	1000	3.8
	12	14.9bc	7.5	1032	4
	16	6.3c	4.9	1028	3.9
LSD (P=0.05)		10.2	5.1	107	0.25
P>F		0.0001	0.4676	0.4092	0.4151
75% OB	UTC	59.6a	15.6a	991	3.8
	8	17.2b	10.3ab	1059	3.9
	12	7.4bc	7.9ab	1002	3.8
	16	5.7c	4.7b	989	3.9
LSD (P=0.05)		10.9	7.8	77	0.21
P>F		0.0001	0.0522	0.2225	0.7795

*Means within a column followed by the same letter are not significantly different.
[1]oz. RU per Acre
[2]Grams of regrowth per meter (3.28 feet) of row
[3]Grams of leaf dry weight per meter (3.28 feet) of row
[4]Lbs of lint Acre^{-1}

Table 4. Greenhouse (GH) and field emergence as affected by rate of glyphosate treatments. Corpus Christi, TX, 1993.

Rate of Application[1]	Seed Produced in position one of:					
	Branch 3		Branch 6		Branch 9	
	GH[2]	Field[3]	GH	Field	GH	Field
	----------% Germination ----------					
UTC	92.5a*	59.a	98.8a	77a	93.8a	75a
8	93.8a	45a	91.3a	45a	97.5ab	11b
12	90.8a	na	91.9a	NA	90.7ab	na
16	90.1a	17b	91.9a	12b	78.8c	5b
LSD (P=0.05)	14.8	24	9.1	48	11.7	39
Pr>F	0.735	0.014	0.45	0.7598	.0081	.0081

*Means within a column followed by the same letter are not significantly different.
[1]oz. RU per Acre
[2]Greenhouse emergence
[3]Field establishment