EFFECTS OF GLYPHOSATE ON ROUNDUP READY COTTON REPRODUCTIVE GROWTH

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Abstract

Roundup Ready technology is an additional tool that can be used against weed problems. However, previous studies have indicated that lint yield can be negatively impacted when plants are treated with over-the-top Roundup applications. Consequently, damage to reproductive organs by glyphosate has been proposed to be one cause of lint yield reduction. In this study Deltapine 5690 RR was cultivated under field conditions. Roundup Ultra was applied using 3 different rates at three different stages of plant growth; 4, 8, and 12-leaf. The rates used bracketed the single over-the-top recommended rate of Roundup Ultra of 1qt/A until the 4-leaf stage. Twelve hours after natural pollination, the degree of anther opening, and the number of pollen grains attached to the stigma were determined for first position flowers. As the rate of glyphosate increased and the stage of application was delayed, a greater number of anthers remained closed and fewer pollen grains were attached to the stigma. This effect was accentuated in nodes 9-11. Pollen tube rate of growth, and travel distance were measured at different times after artificial pollination. No significant differences were found across all treatments. This data suggested that glyphosate has no inhibitory effects on pollen tube growth within the style. Box-mapping data indicated that, as the rate of glyphosate increased and the stage of application was delayed, less retention of first position fruit was observed within node range 6-10. We believe that this reduction in first position fruit retention was due to low pollen availability during pollination. Plants that produced fewer or no first position fruit within nodes 6-10, following glyphosate treatment, attempted to compensate yield losses by shifting fruiting patterns toward more distal positions. The closer the glyphosate application was to floral development, the greater the effect upon pollen availability. We concluded that Roundup Ready cotton yield was negatively affected only at the 12 -leaf stage of application due to low pollen availability in first position flowers within nodes 6-10. Over the top applications of Roundup showed no detrimental effects on lint yield when applied within the labeled rate.

Introduction

Roundup Ready cotton (RR) provides growers with an alternative for enhancing production efficiency, as it represents an additional tool to use against weed problems (White et al., 2000). However, several studies have shown that cotton yield can be negatively affected when Roundup is applied beyond the label (Webb et al ., 1999). For example, in 1998 Kalaher and Coble noticed that glyphosate applications at the eight-leaf stage or above could cause fruit abortion. Moreover, further research also indicated possible glyphosate damage to certain flower parts including pollen grains (Yasuor and Rubin, 2000). Successful pollination is important because fiber production is initiated from the seed surface. Therefore, the potential of reducing yields may be increased as seed number is reduced. Interfering with pollination and the inability to successfully fertilize the ovules may lead to boll abortion.

Several causes may lead to incomplete ovule fertilization; these include reduced pollen availability, insufficient pollen germination on the stigma, inhibition of pollen tube growth within the style, and the potential for unsuccessful fertilization within the ovary. The objectives of this project were to determine the effects of glyphosate over-the-top (OT) application on pollination efficiency of RR cotton by examining pollen availability and pollen tube growth.

Materials and Methods

Deltapine 5690 RR was grown under field conditions in a randomized block design with four replications. Treatments consisted of Roundup Ultra applied at a 0.5, 1, and 2 qt/A at three stages of plant growth: four, eight, and twelve-leaf stages. All possible combinations of these rates and leaf stages, plus the untreated control (UTC), gave a total of 10 treatments. These rates were used to bracket the single over-the-top recommended rate of Roundup Ultra at 1 qt/A until the 4-leaf stage. Each treatment received one single over-the-top application.

For pollen availability and pollen tube growth studies, samples were collected at first position flowers from the three nodes developing above the node at which the Roundup application was made.

To determine pollen availability, flowers were visually rated 12 hours after pollination (HAP) for the degree of anther opening. A rating of 0 indicated that all anthers were closed, 1 that the anthers were partially open (or that the flower had both open and closed anthers), and 2 that all anthers were open. Pollen availability was also determined by counting the number of pollen grains attached to the stigmatic lobe with the highest apparent number of pollen grains. A rating of 0 was given when less than 36 pollen grains were attached to the stigma, 1 from 37-72, and 2 for any number greater than 72.

To measure pollen tube growth, flowers were hand pollinated and then collected at two, four, six, and eight hours. Pollen was obtained from flowers of the untreated plants to assure viability. The pollen tube median position was determined and measured under fluorescence microscopy. The pollen tube median is described as the point at which half of the pollen tubes emerging from the stigma can be counted.

For determining fruiting patterns and boll distribution, six plants were taken from each treatment replication at the end of the season. Additionally, seedcotton weight distribution, plant height, and nodes were determined.

Results

Lint yield was significantly decreased at the 12-leaf compared to the 4- and 8-leaf stage application. To determine why lint yield was decreased from the glyphosate application at the 12-leaf stage, several parameters were examined. The first parameter examined was the degree of anther opening. At 12 HAP the anther opening at node range 9-11 indicated that as the rate of glyphosate increased, and the leaf stage of application was delayed, a greater number of anthers remained closed (Figure 1), suggesting male sterility. At node range 13-15 a similar effect was observed but to a lesser degree, where the differences were not observed until the 8 and 12-leaf stages of application. At node range 13-15, no differences in the degree of anther opening were observed between the UTC and the 4-leaf stage of application.

At node range 9-11, pollen ratings, based on the number of pollen grains attached to the stigma, showed that as the rate of glyphosate increased and the stage of application was delayed, fewer pollen grains were attached to the stigma (Figure 2). At node range 13-15 a similar effect was observed, but to a lesser degree. Differences were not observed until the 8- and 12-leaf stages of application. At node range 13-15, no differences existed between the UTC and the 4-leaf stage of application.

Pollen tube median length measurements taken at different hours after pollination showed no pollen tube growth inhibition occurring within the style. Pollen tube growth rates were calculated at each 2-hour interval. A growth rate could not be taken at 2 hours after pollination because all pollen tubes still remained within the stigma. Even though pollen tube growth rates were significantly different between treatments at 4 hours and 6 hours after pollination, at 8 hours they were not (Figure 3). Similarly, pollen tube median elongation measured as percent of stylar distance showed no evident inhibition occurring within the style (Figure 4). Pollen tube medians across all treatments approached the proximity of the ovary at 8 hours after pollination.

Percent boll distribution based on position showed that the 1 qt rate at the 4-leaf stage was not different from the UTC. As the rate of glyphosate increased and the stage of application was delayed, total 1st position bolls decreased. No differences were noted at the 2nd and 3rd fruiting positions but the plant attempted to compensate for the first position fruit loss by shifting fruiting towards the more distal positions at the later leaf stages of application. However, due to decreased size at more distal positions, lint yield was reduced for the 12-leaf stage.

Percent boll distribution within node ranges as determined by boxmapping (node range 6-10, 11-15, and 16-20), showed no differences between treatments for any of the three ranges. However, the weight distribution within the three nodal groupings showed differences for nodes 6-10. At nodes 6-10, as the rate of glyphosate increased and the stage of application was delayed, seedcotton weight decreased (Figure 5). Because differences were noted only within the nodes 6-10, the percent boll distribution based on position was examined within this range. This analysis showed that as the rate increased and the stage of application was delayed, 1st position fruit was markedly decreased (Figure 6).

Percent ginout increased at the later stages of application, suggesting a decrease in seed size. No significant differences were noted for plant height or total nodes across all treatments.

Conclusions

Above-label applications of glyphosate to Deltapine 5690 Roundup Ready cotton negatively affected 1st-position flower and boll development within the node range 6-10. Pollen availability (number of pollen grains released by stamens) was inversely related to increasing glyphosate rates and application leaf-stage. As the glyphosate rate increased and the leaf stage of application was delayed 1st position fruit decreased.

The closer the application of Roundup Ultra was to floral development, the greater the effect. Within nodes 9-11, at 12 hours after pollination, the number of pollen grains deposited on the stigma for the 4-leaf stage treatments was significantly lower than the number for the untreated control. Four-leaf treatments had significantly more pollen grains attached to the stigma than the 8-leaf. Eight-leaf had higher amounts of pollen than the 12-leaf. For the node range 13-15 a similar effect was observed but to a lesser degree, where the differences were not observed until the 8-and 12-leaf stages of application. No differences in number of pollen grains attached to the stigma were observed between the UTC and the 4-leaf stage.

In general, the reduction of pollen availability affected pollination efficiency on the 12-leaf-stage. Plants within these treatments failed to develop 1st-position fruit on nodes 6-10 and attempted to compensate for this loss by shifting fruiting towards the more distal positions (4th-position fruit). Even though first-position-flower pollen availability was also reduced on the 4- and 8-leaf stage treatments, plants were able to compensate yield losses on more distal positions. This data suggests that glyphosate translocates to the nodes acting as the strongest sinks, primarily at first position flowers.

Pollen tube growth data showed no evident inhibition of pollen tubes occurring within the style. Pollen tube medians across all treatments approached the proximity of the ovary at 8 hours after pollination.

In this study, over the top applications of Roundup showed no detrimental effects on lint yield when applied within the labeled rate.

References

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White, K., D. Beaty, and P. Johnson. 2000. Roundup Ready versus Conventional Cotton Varieties: Case Studies from the Southern High Plains Region of Texas. 2000. Proceedings of the Beltwide Cotton Conference. 1:334-336.

Yasuor, H., B. Rubin, and M Sibony. 2000. Effects of Rate and Time Application of Glyphosate on DP5415RR Cotton in Israel. Proceedings of the Annual California Weed Science Society. California Weed Science Society. 35-39.

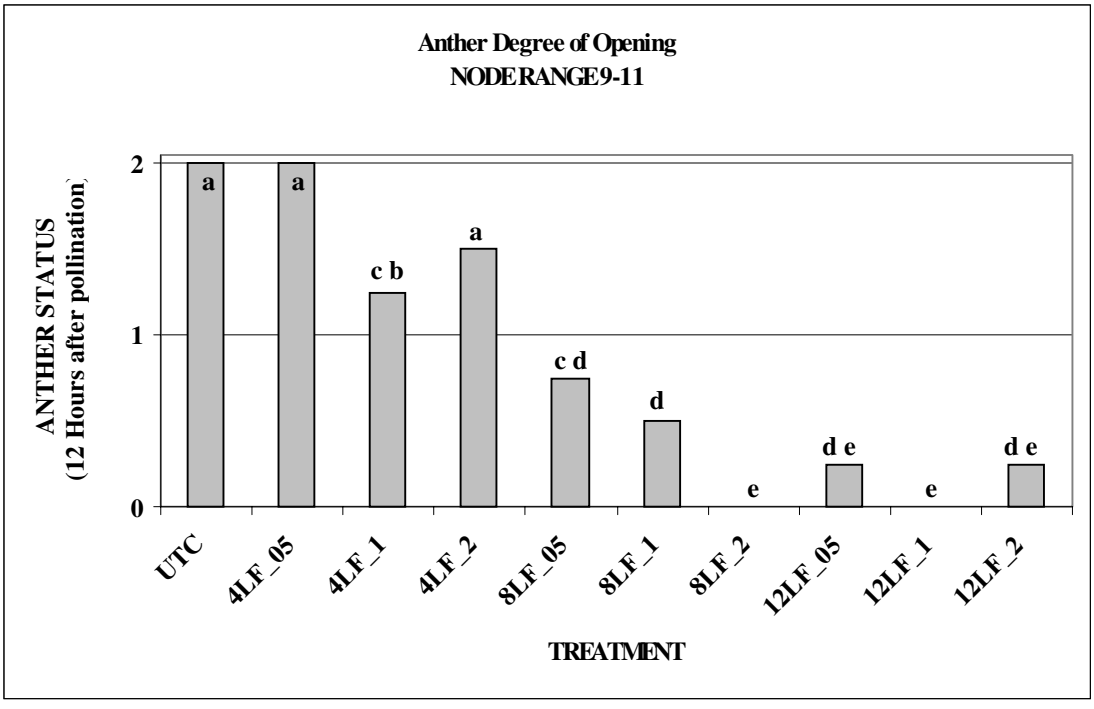

Figure 1. Rating given for the degree of anther opening at 12 HAP (0=Closed; 1=Partially open; 2= Open).

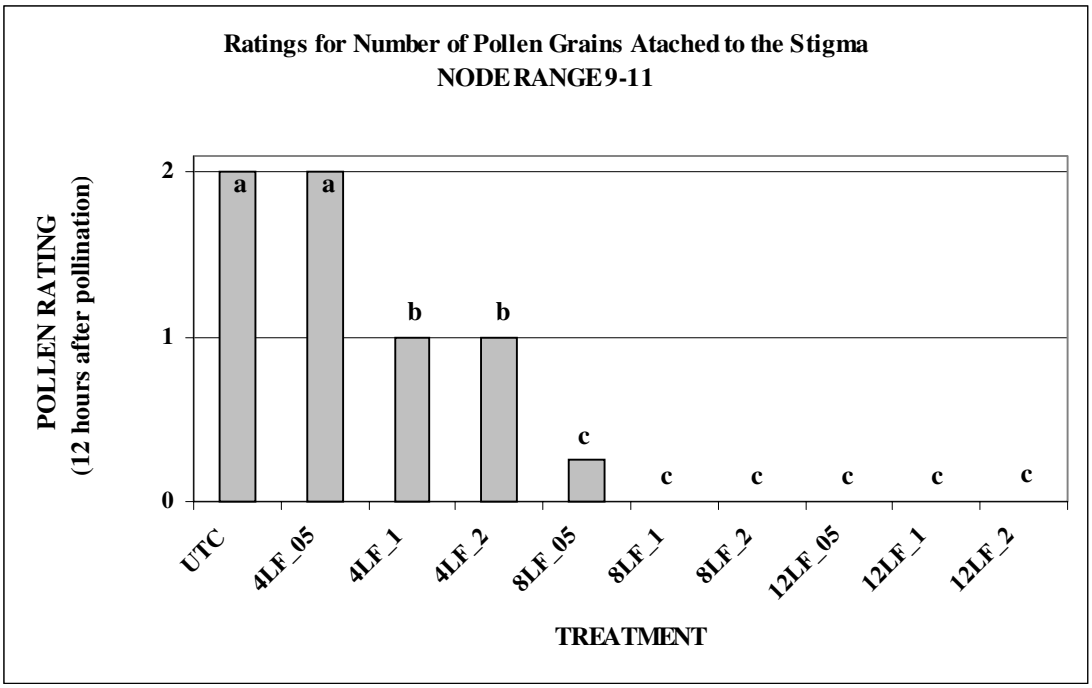

Figure 2. Ratings for the number of pollen grains attached to the stigma at 12 HAP (<36=0; 37-72=1; >72=2).

Pollen Tube Growth Rates at Different Hours After Pollination (HAP)

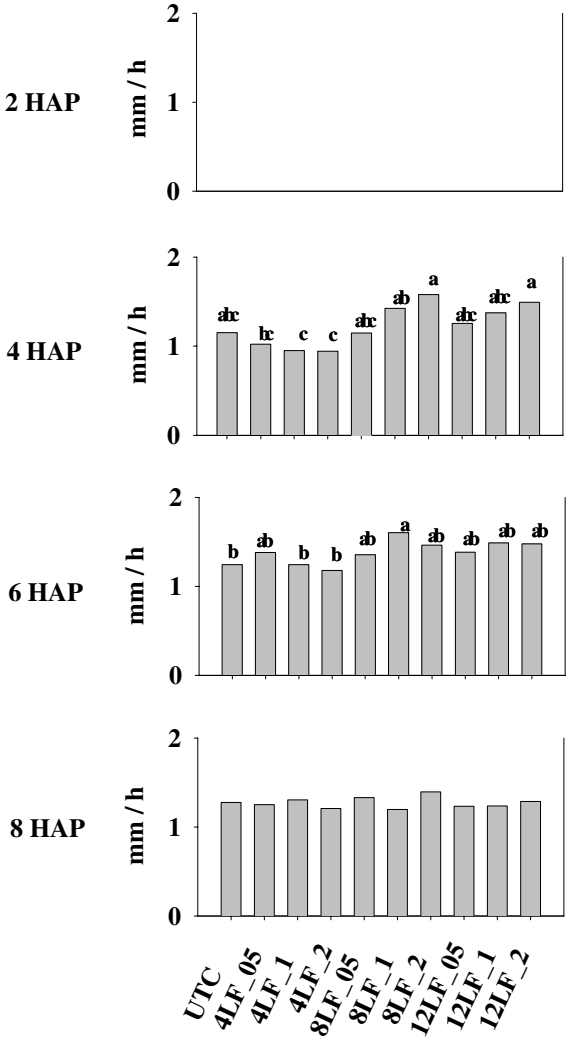

Figure 3. Pollen tube growth rates calculated at each 2-hour interval.

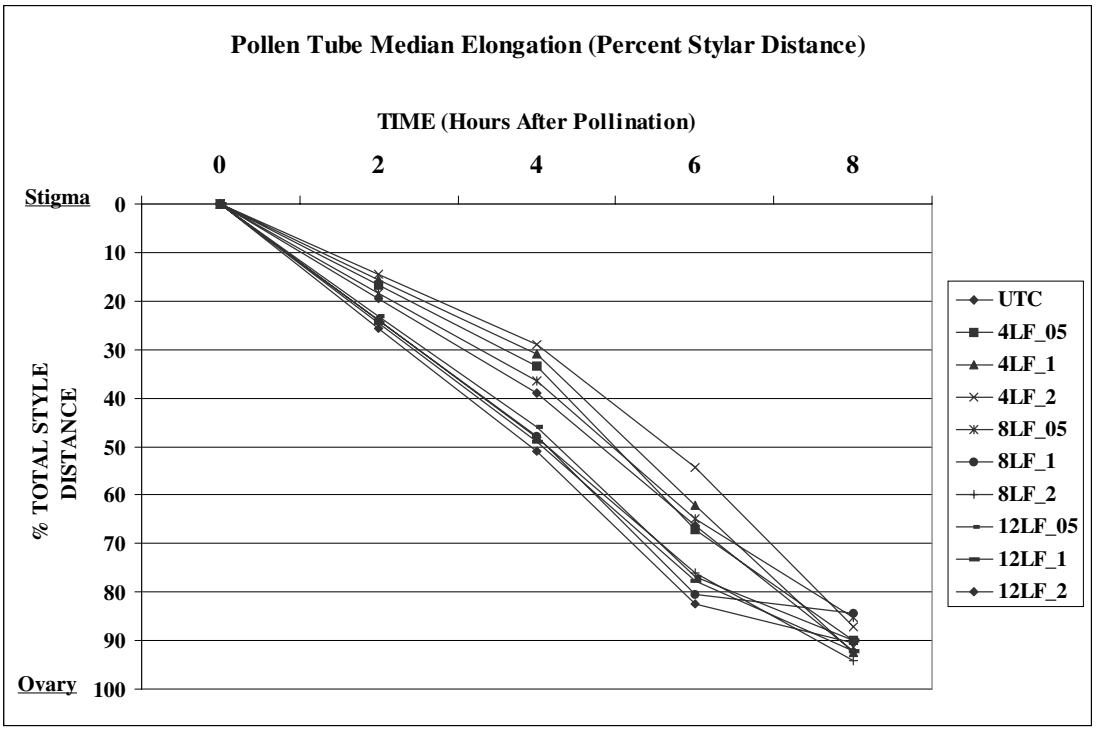

Figure 4. Pollen tube median elongation measured as percent of stylar distance.

Weight Distribution in g
(Total Seedcotton weight of 6 plants)

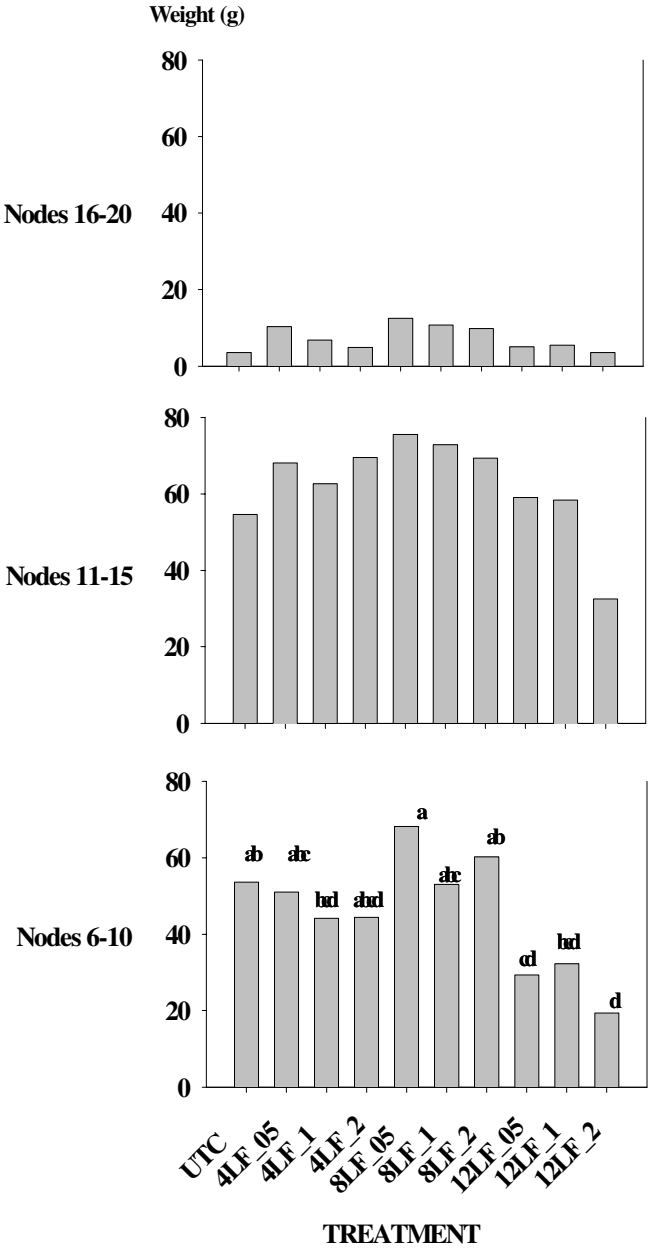

Figure 5. Percent boll distribution within node ranges as determined by box mapping.

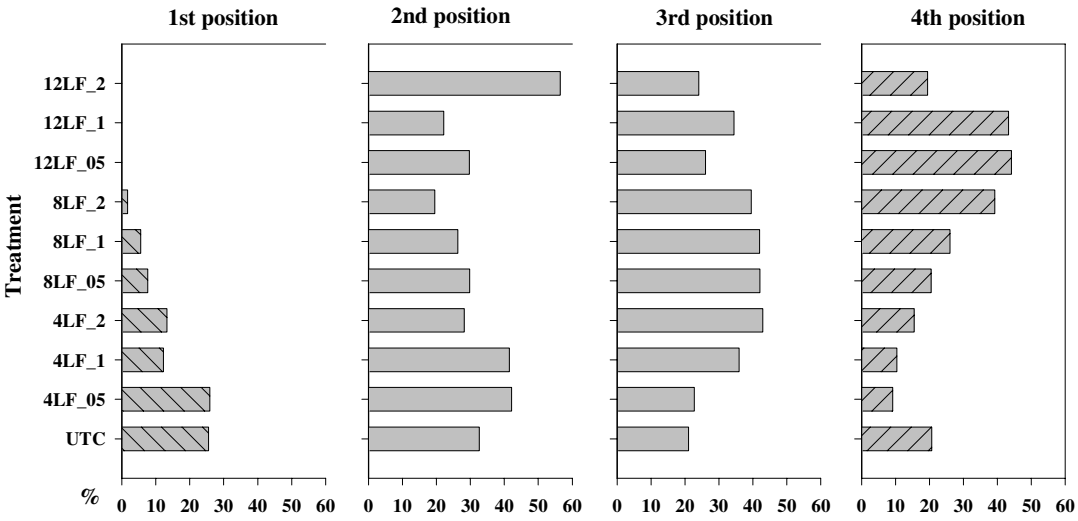

Figure 6. Node range 6-10 percent boll distribution based on boll position.