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Minimal Effects of Foliar Applications of Gibberellic Acid and Carbohydrates on the Yield of Cotton Lint

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Contents

Abstract

Various plant growth hormones and regulators have been reported to increase the yield of cotton (*Gossypium hirsutum* L.) lint when applied to foliage in field tests. We observed positive effects in individual years, but multi-year results were not significant. However, some field tests with gibberellic acid and carbohydrate isolates had shown occasional promise and were the subject of further investigations in 1996 and 1997. In expanded tests in 1996, gibberellic acid did not provide statistically significant increases in lint yield. In a 1997 test, glucose provided a statistically significant increase in lint yield at one location but not at another, while fructose and sucrose did not increase yields at either location. If growth regulators are to consistently affect cotton lint yield, factors such as geography, climate, and procedures must be more precisely defined.

Introduction

Naturally occurring and synthetic bioregulators have an important role in the growth, developmental processes, and yield of plants. They may also induce the biosynthesis of allelochemicals, secondary plant constituents that may protect the plant against infection and injury by plant-eating pests. Consequently, the chemistry and action of these bioregulators are of interest.

In recent years, we have evaluated many kinetin-based commercial plant growth regulators for their effects on cotton plants. In a study at Mississippi State during 1986-1992, five commercial plant growth regulators and urea were evaluated as foliar sprays on growing cotton plants for their effects on yield. Of the five tested at the levels recommended by the providers, the stated activities of three were attributed to cytokinins (Burst, Burst Agritech, Overland Park, Kansas; Foliar Triggrr [FT], Westbridge Agricultural Products, San Diego, California; and Maxon, Terra International, Blytheville, Arkansas). FPG-5 (Baldridge BioResearch, Inc., Cherry Fork, Oklahoma) contained cytokinins, IAA, gibberellic acid, and several inorganic micronutrients. PG-IV (Microflo, Lakeland, Florida) contained IBA, gibberellic acid, and micronutrients, but it contained no cnytokinins. FPG-5 and Foliar Triggrr gave small, consistent yield increases in 1 or more years and significant increases in 1992. Urea had a consistent negative effect on yield. Formulations containing IAA/IBA, gibberellic acid, and inorganic micronutrients also failed to increase yields (Hedin and McCarty 1994a).

Our attention was drawn to one of these commercial plant growth regulators, FT, which gave small, consistent yield increases in field tests each year. In 1992, FT provided statistically significant increases in lint yield. While several cytokinin constituents and preparations performed poorly for us (Hedin and McCarty 1991, 1994a, 1994b), we assume that geographical, climatic, and procedural differences may have been contributing factors to the successful tests with FT by Parker and Salk (1988). They had attributed the activity to cytokinins. However, because we were not able to show yield increases with cytokinins, we hypothesized that, alternatively, one or more unknown components were responsible. This possibility was indirectly supported by the report of Parker and Salk (1988), which described FT as "the product of a fermentation process that is then combined with extracts from a variety of plants which contain naturally occurring growth stimulating substances."

Over a period of several years (1989-1995), we prepared fractions of FT and tested them by foliar application. These fractions, which we found to be rich in carbohydrates, gave consistent, small increases in the lint yield, but they were not statistically significant (Hedin et al. 1997). This report describes our further efforts in 1996 and 1997 to investigate the effects of foliar applications of an occasionally effective growth regulator, gibberellic acid, and of three sugars (glucose, fructose, and sucrose) on the yield and boll size of cotton.

Materials and Methods

1996-1997 Field Tests. The commercial cotton cultivar Deltapine 50 (DPL-50), which is well adapted for the study area, was grown each year on the Plant Science Farm at Mississippi State University. The cotton was planted in single-row plots, 0.97 meter wide and 12.8 meters long. Insects were controlled all season with fenvalerate (DuPont Agricultural Products, Wilmington, Delaware) and malathion (American Cyanamid, Princeton, New Jersey). The growth regulator formulations were applied at three rates, and the carbohydrates were applied at two rates (Table 1 and 2). Treatments were applied to plants whose squares were "match head" (2-4 millimeters) in size.

The gibberellic acid test in 1996 was conducted at two locations. At Location 1, the test was planted on May 7. Gibberellic acid was applied on July 2 and July 16. The plot was harvested on October 18. At Location 2, the test was planted on May 30. Gibberellic acid was applied on July 10 and July 24. The plot was harvested on October 30. In each test, gibberellic acid was applied at the rates of 1, 3, and 10 grams per acre. Each test consisted of six replicates with three rows per replicate.

The carbohydrate test in 1997 was also conducted at two locations. The test was planted on May 12 at Location 1. Applications of glucose, fructose, and sucrose were made on July 3 and July 17. The plot was harvested on October 16. At Location 2, the test was planted on May 14. Applications of glucose, fructose, and sucrose were made on July 11 and July 24. The plot was harvested on October 17. In each test, the same three sugars were applied at the rates of 2 and 10 grams per 0.01526 acre (323.8 and 1,619 grams per hectare). Each test consisted of five replicates with one row per replicate.

Procurement of Test Chemicals. The gibberelic acid (GA_3), glucose, fructose, and sucrose were obtained from Fluka Chemical Corporation, Ronkonkoma, New York, and used as received.

Statistical Procedures. Data obtained from the various analyses and measurements were subjected to the analysis of variance (ANOVA), and least significant difference (LSD) values were calculated according to SAS (1985) methods.

Table 1. Effects of foliar applications of gibberellic acid (GA) to cotton plants, 1996.			
GA level	Lint yield	Boll size	Lint fraction
g/a	lb/A	g	%
Location 1[1]			
0	643	5.24	39.99
1	699	5.39	39.59
3	689	5.27	40.19
10	724	5.10	39.96
F 0.05	NS	NS	NS
Location 2[2]			
0	896	4.96	38.18
1	845	4.80	38.01
3	910	4.82	38.81
10	837	4.69	37.75
F 0.05	NS	NS	NS

[1]The first application at Location 1 was made on July 2; the second, July 16. This test was harvested on October 18.

[2]The first application at Location 2 was made on July 10; the second, July 24. This test was harvested on October 30.

Results and Discussion

Neither the gibberellic acid tests nor the carbohydrate tests provided encouraging results. No statistically significant results were obtained from the gibberellic acid test in 1996 (Table 1 and 2), except that boll size (but not yield) at Location 1 was decreased at the 10-gram applications rate. There were opposing trends regarding yield of lint. The trend was upward at Location 1, but downward at Location 2. As stated earlier, gibberellic acid (and other plant growth regulators) had been evaluated in a series of tests conducted from 1986 to 1992. In some tests, gibberellic acid increased yield by as much as 23.2%, but in other tests, there was essentially no effect (-1.9%) (Hedin and McCarty, 1994).

Statistically significant results were obtained in one instance from the 1997 carbohydrate tests (Table 3). At Location 1, the lint yield was increased by 14.4% and 9% when glucose was applied, while at Location 2, the yield was not significantly increased by glucose application. No statistically significant increases were obtained when either fructose or sucrose were applied. At Location 2, lint yield was increased by 2% at the lower application level of glucose.

Our attention to carbohydrates arose indirectly through our tests with the previously discussed commercial plant growth regulator, Foliar Triggrr. FT gave small, consistent yield increases in field tests each year beginning in 1989. In 1992, FT provided statistically significant increases in lint yield lint: 15.5% at 8 ounces per acre (528 milliliters per hectare); and 12.6% at 16 ounces per acre (1,056 milliliters per hectare) (Hedin and McCarty 1991, 1994a, 1994b). The provider had attributed the activity to cytokinins (Parker and Salk 1988). However, as stated earlier, in a series of tests conducted from 1986 to 1992, the synthetic cytokinin kinetin was evaluated along with kinetin riboside, IAA, and gibberellic acid. The effects of these plant growth hormones were near zero over the 7-year period. Although, in some individual tests, statistically significant differences in yield were obtained (Hedin and McCarty 1991, 1994b).

In our initial investigations with FT, we found that the liquid formulation as supplied by the provider consisted of a black suspension (5% of solids) that could be precipitated and then chromatographed to give a fraction rich in carbohydrates. This fraction provided significant yield increases of 10% at 0.2 kilogram per hectare and 26% at 0.5 kilogram per hectare (Hedin et al. 1997). Over several years (1989-1995), foliar applications of a succession of sugar-containing fractions of FT gave consistent, small increases but not statistically significant lint yield increases. The composition of the active carbohydrate fraction upon acid hydrolysis was found mainly to be a mixture of monosaccharides and disaccharides, with some sulfated polysaccharides. Equal molar formulated mixtures of sugars (mannose, galactose, glucose, and sucrose) and of several isomeric carrageenans (linear sulfated polysaccharides) provided small, consistent increases, but they were not statistically significant (Hedin et al. 1997).

Therefore, our tests with carbohydrates in 1997 were carried out to determine whether any of three widely distributed sugars in nature (glucose, fructose, and sucrose) would have a statistically significant impact on yield. Unfortunately, we were able to demonstrate only a minimal positive impact. We apparently have been unable to define the precise application regimens required to elicit consistent positive responses. These requirements may include factors such as geography, temperature, sunlight, nozzle pressure, cultivar, timing of application, and status of soil and plant nutrients.

Table 2. ANOVA of foliar applications of gibberellic acid (GA) over locations for 1996.

GA Level	Means over two locations		
	Lint yield	Boll size	Lint fraction
g/a	lb/A	g	%
0	769	5.10	39.08
1	772	5.09	38.80
3	800	5.05	39.50
10	780	4.89	38.85
F 0.05	NS	*	NS
LSD 0.05		0.12	
Loc 1	872	4.82	38.19
Loc 2	689	5.25	39.93
LSD 0.05	42	0.09	0.96
ANOVA			
Loc	*	*	*
Lev	NS	*	NS
Loc *Lev	NS	NS	NS

Table 3. Effects of foliar applications of glucose, fructose, and sucrose to cotton plants, 1997.

Chemical	Level			Lint	Boll size	Lint yield
	g/0.01526 A	g/ha	moles/ha	%	g	lb
Location 1[1]						

Glucose	0	0.0	0.0	39.77	4.95	1,265
	2	323.8	5.4	38.98	5.36	1,448
	10	1,619.0	27.0	38.31	5.02	1,380
	LSD 0.05			1.15	NS	149
Fructose	0	0.0	0.0	39.77	4.95	1,265
	2	323.8	5.4	39.65	5.07	1,293
	10	1,619.0	27.0	39.83	5.16	1,345
	LSD 0.05			NS	NS	NS
Sucrose	0	0.0	0.0	39.68	4.95	1,295
	2	323.8	2.7	40.07	4.97	1,305
	10	1,619.0	13.5	39.16	4.77	1,236
	LSD 0.05			NS	NS	NS
Location 2[2]						
Glucose	0	0.0	0.0	39.23	5.08	975
	2	323.8	5.4	40.93	4.97	894
	10	1,619.0	27.0	39.01	5.01	835
	LSD 0.05			1.63	NS	NS
Fructose	0	0.0	0.0	39.23	5.08	975
	2	323.8	5.4	38.12	4.93	842
	10	1,619.0	27.0	37.97	5.08	963
	LSD 0.05			NS	NS	NS
Sucrose	0	0.0	0.0	39.86	4.99	927
	2	323.8	2.7	40.25	5.06	906
	10	1,619.0	13.5	39.79	4.76	962
	LSD 0.05			NS	NS	NS

[1]Location 1 was planted May 12, using the variety Deltapine 50. The first application was made July 3; the second, July 17. Cotton was harvested October 16. This test consisted of five repetitions, one row per repetition.

[2]Location 2 was planted May 14, using the variety Deltapine 50. The first application was made July 11; the second, July 24. Cotton was harvested October 17. This test consisted of five repetitions, one row per repetition.

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