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LOSS OF APICAL DOMINANCE IN DP 444 BG/RR: EFFECT ON YIELD, FIBER QUALITY, AND MATURITY

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Abstract

Field observations in 2002 suggested a consistent incidence of plants lacking apical dominance ('split terminal plants') in DP 444 BG/RR, a new early-maturing variety from Delta and Pine Land Company. We collected data across the U.S. cotton belt in 2002 and 2003 to determine the incidence of split terminal plants in DP 444 BG/RR, as well as to determine the effect on yield contribution, fiber properties, and maturity. The loss of apical dominance occurred in about 24% of the plants of DP 444 BG/RR over two years. The application of glyphosate over-the-top did not influence the incidence of split terminals in this variety. The breadth, consistent timing and incidence of split terminal plants across a wide geographic area over two years strongly suggest that insect injury was not likely responsible for this phenomenon. However, insect or other physical injury could add to the average level of plants exhibiting loss of apical dominance. Split terminal plants contributed equally to crop yield, and did not influence any of the fiber properties. Split terminal plants had significantly fewer total nodes and significantly fewer fruiting nodes, but averaged 2.2 well developed monopodia per plant. Flower initiation was significantly delayed an average of 1.4 nodes in split terminal plants of DP 444 BG/RR, but final maturity was not delayed. Our data suggest that the occurrence of split terminal plants in DP 444 BG/RR did not alter the manner in which the variety should be managed for glyphosate applications, insect control, or harvest aid applications relative to other early-maturing varieties.

Introduction

Delta and Pine Land Company (D&PL) recently developed a new early-maturing variety, DP 444 BG/RR. Field observations in 2002 suggested a consistent incidence of plants exhibiting a lack of apical dominance. D&PL technical service agronomists noted this phenomenon at every location observed in 2002.

'Split terminal' plants or 'tipped out' plants can result from a number of events that remove or damage the apical meristem, such as plant bug injury (Horn, et al., 1999), thrips injury (Cook et al., 1998), injury from Lepidopterous pests (Lei and Gaff, 2003), or from mechanical damage or physical breakage of the apical meristem due to hail or contact with field equipment. Most research suggests this early season terminal injury may induce vegetative growth and delay maturity (Horn et al., 1999).

Numerous entomological studies have documented the compensatory ability of the cotton plant after experiencing apical meristem injury (Lei and Gaff, 2003). Plants that were tipped out (terminals removed) at the fourth true leaf stage had significantly more vegetative bolls, but had similar number of bolls per plant and seedcotton yield compared to control plants. Additionally, tipped out plants reached 100% open bolls at the same time as the control plants (Lei and Gaff, 2003).

Very little research has been conducted investigating the genotypic effects on apical dominance or on the compensatory ability of cotton plants that lose apical dominance. Sadras and Fitt (1997) found considerable variability in the degree of apical dominance among cotton genotypes. 'Normal' genotypes tended to be taller, required more time to activate secondary buds following the release of apical dominance, and tended to be less resistant to insect feeding by *Helicoverpa* spp. and mirid bugs (*Creontiades dilutus* Stal and *Campylomma lividia* Reuter) versus genotypes exhibiting less apical dominance. However, their studies also suggested that the effects of the loss of apical dominance on insect resistance can be influenced by a number of other traits, including other host plant resistance characteristics, such as condensed tannin and terpenoid aldehyde levels.

We collected data from plots and fields of DP 444 BG/RR during 2002 and 2003 to determine the incidence of 'split terminal' plants (those that had lost apical dominance), the stage at which apical dominance was lost, and the effects on yield, fiber quality, and maturity of this variety.

Materials and Methods

Immediately following the initial observations of consistent loss of apical dominance in some plants of DP 444 BG/RR in 2002, we began collecting incidence data at nearly 30 locations across the U.S. cotton belt based on the percent of the total stand comprised by split terminal plants. Additionally, in 2002 at replicated trial locations in Winterville, Mississippi (one location) and Hartsville, South Carolina (three locations), we collected the following data: split terminal plant incidence, plant height, total nodes, vegetative nodes, fruiting nodes, height-to-node ratio, the number of bolls per plant, and the nodes above cracked boll during the early stages of boll opening. At these locations, 10-ft sections of seedcotton were hand-harvested per replicate; seedcotton from each plant type ('normal' vs. 'split terminal' were collected and ginned separately on a 20-saw laboratory gin. Fiber samples from each plant type and replicate were sent to D&PL's High Volume Instrument (HVI) laboratory for fiber analysis.

In 2003, we recorded the node at which apical dominance was lost, the number of fruit-producing monopodia resulting on split terminal plants, the node of the first position flower during early bloom, nodes above cracked boll during early boll opening, and split terminal incidence from DP 444 BG/RR plots and/or fields at 16 locations throughout the U.S. cotton belt. At each of these locations, we hand-harvested seedcotton separately from normal and split terminal plants from 4 random areas of 10 row-feet each. Samples were ginned on a 20-saw laboratory gin, and fiber samples were analyzed by D&PL's HVI laboratory.

Statistical analysis included t tests to determine if yield, fiber quality, and maturity characteristics were different between the two plant types.

Results and Discussion

Incidence of Split Terminal Plants

Split terminal plants occurred in 24.9% of the total stand in 2002 (Table 1) and in 23.9% of the total stand in 2003 (Tables 2 and 3). In both years, split terminal plants were found at every location. Split terminal plant incidence ranged from 10.9 to 46.2% of the total stand in 2003 (Table 2). The node at which apical dominance was lost was between 2.0 and 3.8, with a mean of 2.7 in 2003. The resulting fruit-producing monopodia (i.e., resulting monopodia that did not produce fruit were not counted) following the loss of apical dominance ranged from 1.4 to 2.7 per plant, with a mean of 2.2 per plant (Table 2).

Effect of Glyphosate Application

Since the node at which the loss of apical dominance occurred closely coincides with the stage of growth at which over-the-top applications of glyphosate are made on Roundup Ready® varieties, we recorded data from our Roundup Ready® gene equivalency trials in which glyphosate applications are made on a split plot arrangement (i.e., half the plots of each variety were sprayed with glyphosate; the other half remained unsprayed). Data collected at Winterville, MS and Hartsville, SC in 2002 indicate no significant difference between plant types for split terminal incidence. Plots sprayed with glyphosate over-the-top had 19.0% split terminal plants in the total stand, while unsprayed plots had 18.4 % split terminal plants (Prob>|t|=0.8248).

Plant Stucture

Plants with split terminals tended to be numerically shorter, but had significantly fewer total nodes than normal plants. This is consistent with the effects of a higher population (split terminal plants averaged 2.2 well developed monopodia per plant). Kerby et al. (1990) demonstrated that for five genotypes, increasing plant density decreased final height and reduced the number of main stem nodes. This effect was greatest for genotypes with high early fruit retention. Plants with split terminals exhibited growth characteristics similar to what would be expected from plants grown in a higher plant density. The number of vegetative nodes did not differ between the two plant types, but split terminal plants had significantly fewer fruiting nodes per plant. Height-to-node ratio and the number of harvestable bolls per plant were not different for the two plant types (Table 1).

Yield Contribution

In both years, the percent of the lint yield contributed by the split terminal plants closely matched the percent of the total plant stand these plant types comprised (Tables 1 and 3). T-tests confirmed that the split terminal plants contributed equally to yield compared to the normal plants, suggesting that the loss of apical dominance in DP 444 BG/RR did not significantly influence yield. Percent turnout did not differ between the two plant types in either year (Tables 1 and 3).

Fiber Quality

None of the fiber properties were significantly different between the plant types in either year (Tables 1 and 3), indicating the loss of apical dominance did not alter the fiber properties of DP 444 BG/RR. Since DP 444 BG/RR has had high yield performance with micronaire averaging in the premium range across the U.S. cotton belt, and since high-yielding varieties typically tend to produce micronaire in the high discount range (a cross-linkage plaguing the breeding industry for decades), we wanted to determine if the lower micronaire accompanying the high yield performance of DP 444 BG/RR was in any way related to the loss of apical dominance in some plants. Our detailed data clearly indicate micronaire (and all other fiber quality factors) are the same for normal and split terminal plants.

Maturity

In 2002, final maturity was not delayed in split terminal plants, as measured by nodes above cracked boll (Table 1). We theorized in 2002 that the initiation of flowering was likely delayed in split terminal plants, due to the loss of the apical meristem. Kerby et al. (1987) demonstrated first position flowers on monopodia (counting nodes on monopodial branches as a continuation of the main stem) were approximately 150 DD_{60} later than sympodial first position flowers at the same node. Therefore in 2003, we recorded the node of the first position flower during early bloom for each plant type. Our data suggest the initiation of flowering is significantly delayed by 1.4 nodes for split terminal plants compared to normal plants (Table 3). However, final maturity, as in 2002, was not delayed in split terminal plants, as evidenced by the 2003 nodes above cracked boll data in Table 3. Because split terminal plants averaged 2.2 well developed monopodia per plant, the same number of bolls were set in fewer nodes and cut out occurred at a similar time even though flowering was delayed by 1.4 nodes on average.

Summary

The loss of apical dominance occurred in about 24% of the plants of DP 444 BG/RR over two years. While we did not determine the cause of the loss of apical dominance in this variety, our data show it is not due to applications of glyphosate. The occurrence of split terminal plants at every location in 2002 and 2003 strongly suggests that insect injury is not responsible for the occurrence of the consistent incidence of the loss of apical dominance in DP 444 BG/RR. The likelihood of having insect populations infest the crops at the same stage (between nodes 2 and 3) and at such a consistent rate (approximately 24% of the total stand) across a wide geographic area is very low. Split terminal plants contributed equally to crop yield, and did not influence any of the fiber properties. Split terminal plants had significantly fewer total nodes and significantly fewer fruiting nodes. Split terminal plants' flower initiation was significantly delayed, but final maturity was not delayed. Our data suggest that the occurrence of split terminal plants in DP 444 BG/RR did not alter the manner in which the variety should be managed for glyphosate applications, insect control, or harvest aid applications relative to other early-maturing varieties.

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Table 1. Characteristics of 'normal' and 'split terminal' plants of DP 444 BG/RR in Mississippi (one location) and South Carolina (three locations) in 2002.

Characteristic	# locations	Plant Type† Normal Terminal Plants	Plant Type† Split Terminal Plants	t test‡ (Prob > |t|)
% Plant Stand	4	75.1	24.9¶	<0.0001
Yield Characteristics				
% Yield Contribution	4	76.3	23.7¶	<0.0001
% Turnout	4	41.4	42.0	0.6090
Fiber Quality Characteristics				
Micronaire	4	3.95	3.81	0.3322
Length (in)	4	1.09	1.07	0.5691
Strength (g/tex)	4	29.6	29.5	0.8466
Uniformity (%)	4	86.0	85.6	0.7435
Leaf Grade	4	2.5	2.3	0.8180
Plant Structure Characteristics				
Plant Height (in)	4	40.3	35.8	0.2912
Total Nodes	4	19.6	16.0	0.0020
Vegetative Nodes	4	4.5	4.6	0.6544
Fruiting Nodes	4	15.1	11.4	0.0016
Height-to-Node	4	2.05	2.22	0.3200
Ratio (in/internode)	4	14.2	12.9	0.4431
Bolls/plant	4	7.6	7.9	0.7095
Nodes Above Cracked Boll				

† 'Split Terminal Plants' were those exhibiting a loss of apical dominance by the presence of one or more monopodia and the absence of a mainstem. 'Normal Terminal Plants' had typical mainstems and exhibited apical dominance.

‡ Probability that the values for a particular characteristic do not significantly differ between plant types (normal terminal vs. split terminal plants).

¶ These two values (% Yield Contribution and % Plant Stand for Split Terminal Plants) did not differ significantly, according to t test (Prob>|t| = 0.6499).

Table 2. Incidence, node at which apical dominance was lost and how many fruit-producing monopodial branches resulted in 'split terminal plants' plants of DP 444 BG/RR in 16 fields across the cotton belt in 2003.

Statistic	Split Terminal Plant Incidence (% of stand)	Average Node of Split†	Average no. of monopodia‡
Mean	23.9	2.7	2.2
Maximum Value Observed	46.2	3.8	2.7
Minimum Value Observed	10.9	2.0	1.4
Standard Deviation	10.5	0.5	0.3

† Node (from the base of each plant; cotyledonary node = 0) at which 'Split Terminal Plants' lost apical dominance and began producing one or more monopodia.
‡ Number of fruit-producing monopodia for 'Split Terminal Plants'.

Table 3. Characteristics of 'normal' and 'split terminal' plants of DP 444 BG/RR in fields across the cotton belt in 2003.

		Plant Type†		
Characteristic	# locations	Normal Terminal Plants	Split Terminal Plants	t test‡ (Prob > |t|)
% Plant Stand	16	76.1	23.9¶	<0.0001
Yield Characteristics				
% Yield Contribution	16	75.2	24.8¶	<0.0001
% Turnout	16	40.6	40.5	0.9274
Fiber Quality Characteristics				
Micronaire	15	3.74	3.75	0.9552
Length (in)	15	1.12	1.12	0.7873
Strength (g/tex)	15	31.7	31.4	0.7528
Uniformity (%)	15	83.1	82.8	0.6103
Yellowness (+b)	13	7.4	7.3	0.9063
Reflectance (% Rd)	13	77.6	78.1	0.7137
Leaf Grade	14	2.4	2.0	0.5224
Maturity				
Node of First Position Flower during early bloom	16	9.4	8.0	0.0447
Nodes Above Cracked Boll	13	6.4	6.2	0.8527

† 'Split Terminal Plants' were those exhibiting a loss of apical dominance by the presence of one or more monopodia and the absence of a mainstem. 'Normal Terminal Plants' had typical mainstems and exhibited apical dominance.
‡ Probability that the values for a particular characteristic do not significantly differ between plant types (normal terminal vs. split terminal plants).
¶ These two values (% Yield Contribution and % Plant Stand for Split Terminal Plants) did not differ significantly, according to t test (Prob>|t| = 0.8370).