YIELD DYNAMICS OF TWO COTTON VARIETIES IN GEORGIA

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Abstract

In Georgia, the dominant cotton variety is Delta & Pineland 555 BR, while in West Texas, FiberMax 960 B2R and 9063 B2RF are commonly grown, high-yielding varieties with good fiber quality parameters. Several factors may play roles in the performance and popularity of these varieties, including season length characteristics of both varieties and phenotypic response to the very different environments between Georgia and West Texas. The objective was to determine growth characteristics of these two varieties in Texas and Georgia to determine growth and source-to-sink relationships in each environment based on temperature, sunlight, and precipitation/soil moisture. However, due to hail at the Texas location, the study was conducted at two locations in Georgia in 2007. In 2008, the study was conducted at one location in Georgia and one in Texas. The parameters were used to ascertain contributing factors to the yield and quality of the plants. There was a unique variety affect on fruiting response and growth response throughout the season, and these changes in fruiting and growth response can potentially affect yield and/or quality.

Introduction

The most commonly grown variety of cotton in Georgia is Delta & Pine Land 555 Bollgard / Roundup Ready (DP555). Although this variety yields well in Georgia, its quality is average at best. In other locations of the Cotton Belt, DP555 is not grown as commonly as it is in Georgia. Some of this difference may be attributable to differences in growing season and climate. Georgia has mild falls, during which cotton will continue to grow after the point at which it would be considered completely mature in other regions of the cotton belt. Georgia also has cloudy days, limiting daily incoming solar radiation. In addition, because peanut harvest occurs at the same time as cotton harvest, producers typically leave the cotton crop out in the field longer than another regions of the cotton belt. This allows a full season variety like 555 to continue to increase its yield potential, provided water and nutrients are available for the plant to grow.

Cotton has been shown to have different fruit development and distribution patterns based on several factors, including variety, water application, plant density, and PGR application (Bednarz et al., 2000; Dumka, 2002; Dumka et al., 2004). Cotton has also been shown to have differential yield distribution based on the genetic technology (BG vs. BG2 and RR vs. RRF) (Mills et al., 2008).

One of the questions surrounding 555 fiber quality is whether this decrease in quality is due to a longer fruiting period, the production of late maturing bolts that appear at the top of the plant, the size of the bolls that are produced in the plant, differences in carbon partitioning, or some other factor, such as within-boll fiber growth. To identify some of these potential issues, Delta & Pine Land 555 BG/RR (DP555) and FiberMax 960 BGII/RRFlex (FM960) were grown together under dryland and irrigated conditions to identify growth habits, water uptake, and yield distribution.

Materials and Methods

In the 2007 study in Georgia, Delta & Pineland 555 BG/RR and FiberMax 960 BGII/RF were planted at the density of 3.5 plants/foot on May 9 in the Newton field of the Stripling Irrigation Research Park in Camilla, Georgia, and on May 17 (Newton) at the Lang Research Farm in Tifton, Georgia (Lang). The plot layout was a split plot design, with irrigation as the main plot and variety as the split plot. The irrigation treatments consisted of a dryland treatment and a fully irrigated treatment, which were laid out in a randomized complete block design. The varieties were planted side-by-side in four row plots in the center of each irrigation treatment. Watermark sensors were placed in the second row of each irrigation treatment to monitor soil moisture. At the Stripling irrigation Research Park, the watermark sensors were placed in four replicates of each treatment, but at the Lang farm, the sensors were only placed in two replicates of each treatment. Growth analysis measurements were made throughout the season, at two week intervals, including radiation capture measurements, soil moisture, plant height, notes above first square / white flower, and in-season fruit distribution.

In 2008, the experiment was repeated on adjacent plot space at the Newton field with the same main plots and split plots as in 2007. FiberMax discontinued FM 960 in most of the cotton belt after 2007, so FiberMax 9063 was planted instead in Georgia and Texas. In Georgia, the study was planted on May 17, 2008.

In-season yield distribution was measured nondestructively. Five plants in each plot were selected based on uniformity, lack of plant damage, and consistent row spacing (no plants with gaps of more than 6 inches on either side were selected). These plants were marked by tying a strip of flagging tape loosely around the base of the plant and staking the tape across the row. At first square and at selected intervals afterward (every two weeks in 2007, and every week in 2008), the location and maturity of each fruiting structure on each plant was tabulated. Plastic nursery tabs were attached to fruiting branches at nodes 5, 10, and 15 (when necessary) for ease of counting and to minimize node counting mistakes. Each fruiting structure counted was assigned a growth stage, with 4 growth stages between pinhead square and white flower and 5 boll sizes from early boll to completely filled boll. Fruiting structures from adjacent plots were removed, sorted by size and stage, dried, and weighed to provide a representative estimate of fruiting structure dry biomass. The average of at least 20 fruiting structures of each size was used to determine average dry fruit biomass. These dry mass numbers were then concatenated to in-season growth stage measurements to estimate fruit mass by node and fruiting position over the growing season.

At the end of the season, each tagged plant was removed, and the fruit distribution was determined using box-mapping. Fruit from all plants in a plot was pooled, and the total bolls and total boll mass at each node and position, in addition to vegetative bolls and lost cotton were measured. Lost cotton was in all cases less than 1% of the total boll mass for each plot.

Due to the large amounts of data associated with this study, all figures will be shown from the Newton studies. Plant height was not significantly different between treatments until 44 DAP, when the non-irrigated treatments began to lag in growth (Figure 1). On day 50, the DP555 variety began to show significant differences in height with FM960. These differences continued throughout the growing season. The non-irrigated DP555 attained the same height as the irrigated FM960 by 86 DAP and trended higher at 99 DAP.

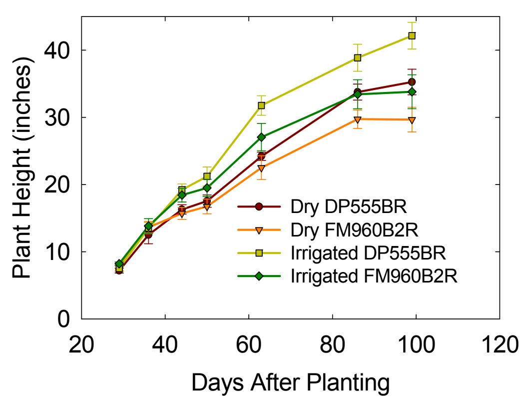

Figure 1. Height of irrigated and non-irrigated DP555 and FM960 at the Newton location during 2007. Error bars represent standard error of the mean (n = 8).

Radiation capture, defined by the equation 1, showed similar trends to those of plant height (Figure 2). Significant differences between irrigated treatments were seen by day 44, and these differences were evident until day 90. Prior to day 50, FM960 showed higher fractional PPF absorbed, but on day 69, DP555 showed a higher fractional PPF absorbed.

Equation 1

$$PPF_{abs} = \frac{PPF_{incident} - PPF_{reflected} - PPF_{transmitted} + R_{soil} \times PPF_{transmitted}}{PPF_{incident}}$$

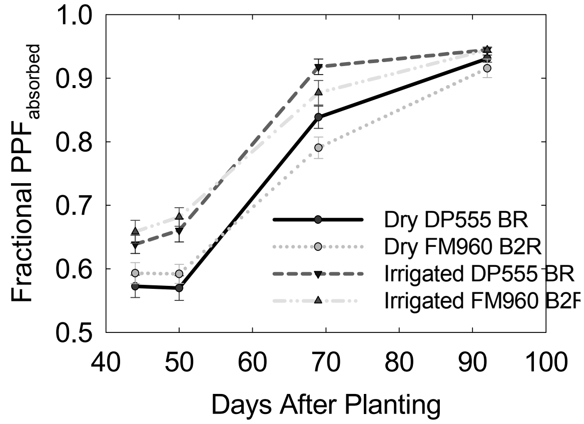

Figure 2. Radiation capture, expressed as fractional $PPF_{absorbed}$ for irrigated and non-irrigated DP555 and FM960 varieties in 2007. Error bars represent standard error of the mean (n = 8).

Because DP555 was consistently taller, but did not consistently have higher PPF absorbed than FM960, plant height and fractional PPF absorbed were compared for the two varieties. FM960 exhibited higher fractional PPF absorbed at height below 30 inches than DP555. Above 30 inches, the radiation capture curves were not different.

The DP555 FM960 showed significant differences in fruiting distribution both during the season and at the end of the season at the end of the season, as shown in Figure 3 and Figure 4. Some of these changes were evident at 50 days after planting (Figure 3), where the irrigated DP555 cotton showed a distribution that trended toward the higher vertical nodes than the other treatments. This difference was more pronounced at 63 days after planting, when the irrigated DP555 cotton showed a significant increase in boll number at the higher vertical nodes (nodes 14 and above) than the irrigated FM960, and the non-irrigated DP555 showed a distribution almost identical with the irrigated FM960 and distributed higher vertically than the non-irrigated FM960. By day 78, both the irrigated and non-irrigated DP555 treatments showed a dramatic shift toward the higher vertical nodes on the plant. These differences were reflected in the final yield distribution at harvest (Figure 4), where the DP555 variety showed significantly more fruit at the higher vertical nodes than FM960.

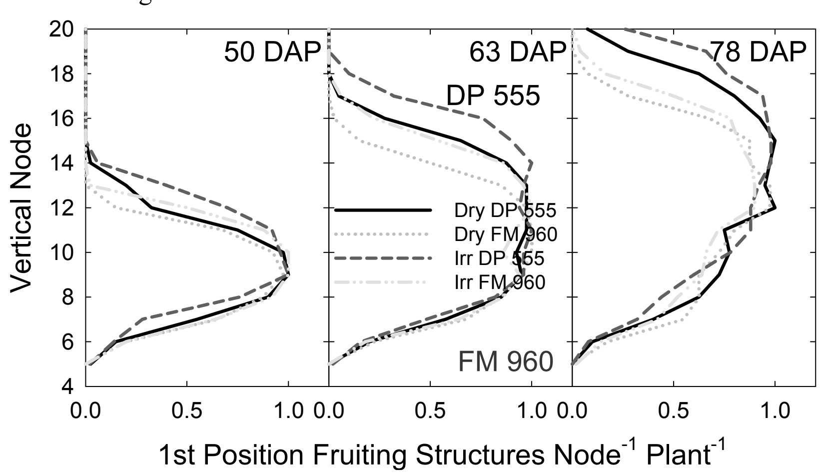

Figure 3. First position fruit per node per plant at 50, 63, and 78 days after planting. Values are means of 8 replicates.

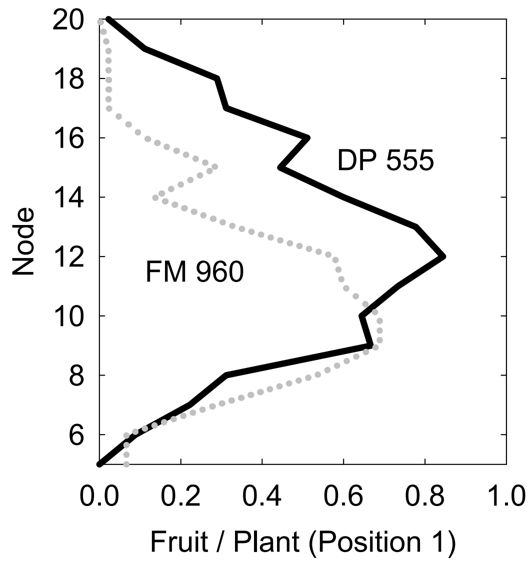

Figure 4. First position fruit per plant by node at harvest.

FiberMax 960 had significantly higher fruit weight below node ten at the first position, whereas Delta and Pine land 555 had higher fruit mass from nodes 12 through node 19 first position (Figure 5). DP555 also had higher fruiting distribution above node 10 in the second sympodial position. This difference was attributed to the increased boll numbers in these regions (Figures 4 and 5).

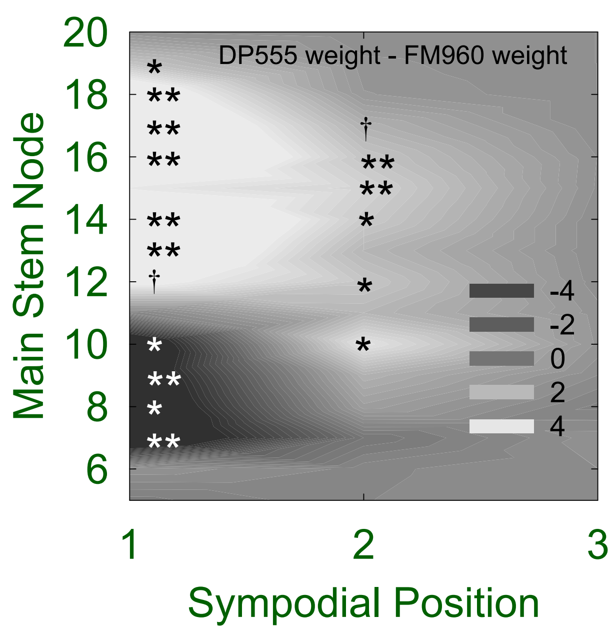

Figure 5. Difference in boll mass by main stem node and sympodial fruiting position between DP555 and FM960. Light regions of the graph indicate areas of the plant where DP555 has higher fruit mass than FM960, while dark regions indicate areas of the plant where FM960 has higher fruit mass than DP555. Symbols represent significance: † P<0.10; *P<0.05; **P<0.01

FiberMax 960 had significantly higher average boll weight then DP555 at almost every node (Figure 6), suggesting more carbohydrate partitioning to the production of each boll in FM960 then in DP555. As shown in Figure 5, DP555 had significantly higher fruit numbers at the higher nodes. Much of the late production of fruit was identified in season (Figure 4).

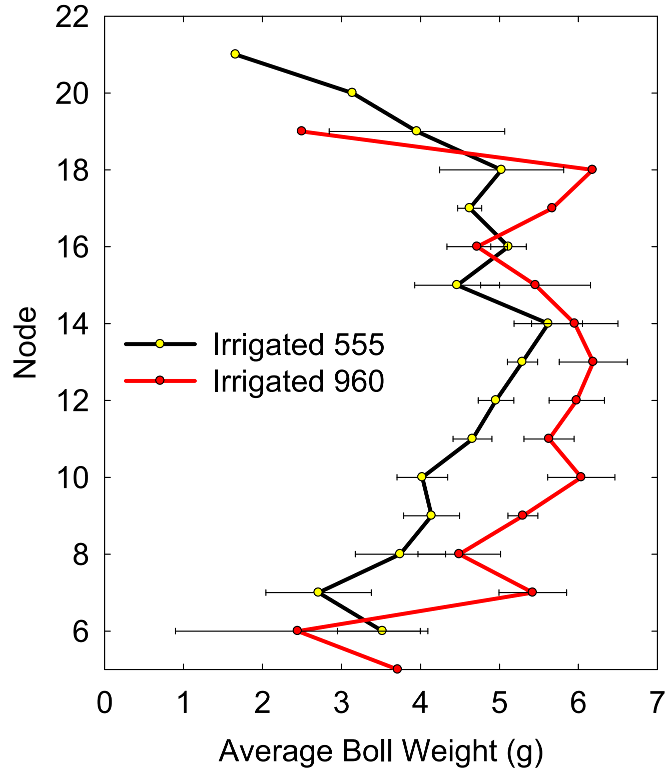

Figure 6. Average boll mass by node of irrigated DP555 and FM960. Error bars represent standard error of the mean (n = 8).

FiberMax 960 had significantly higher fiber length, fiber uniformity, and fiber strength. However, the micronaire content was higher in FiberMax 960 than in DP555. Irrigation did not have an effect on length, uniformity, and strength, but did have an effect on micronaire (P=0.0642), as shown in.

Table 1. Effect of irrigation on yield, turnout, and fiber quality.

	Dry	Irrigated	P-Value
Seed Weight	3894	4289	0.0036**
Lint Weight	1425	1569	0.0048**
Turnout	0.3641	0.3648	0.7003
Staple	35.94	36.00	0.6587
Micronaire	4.725	4.625	0.0642†
Strength	31.10	30.72	0.5937
Length	1.1188	1.1213	0.6216
Uniformity	0.8115	0.8118	0.8606

Table 2. Effect of variety on yield, turnout, and fiber quality.

	DP555BR	FM960B2R	P-Value
Seed Weight	4440	3743	<0.0001**
Lint Weight	1690	1304	<0.0001**
Turnout	0.381	0.348	<0.0001**
Staple	35.1	36.8	<0.0001**
Micronaire	4.6875	4.6625	0.632
Strength	30.21	31.61	0.0597†
Length	1.095	1.145	<0.0001**
Uniformity	0.8093	0.814	0.0136*

Table 3. Newton 2007 yield and fiber quality: interaction of variety and irrigation.

	Dry DP555	Dry FM960	Irrigated DP555	Irrigated FM960	P-Value Irr*Var
Seed Weight	4359	3429	4521	4057	0.0683†
Lint Weight	1655	1195	1726	1413	0.1222
Turnout	0.3797	0.3484	0.3816	0.348	0.5449
Staple	35	36.875	35.25	36.75	0.1923
Micronaire	4.76	4.69	4.61	4.64	0.3417
Strength	30.4	31.8	30.0	31.4	0.979
Length	1.0925	1.145	1.0975	1.145	0.6216
Uniformity	0.811	0.812	0.8076	0.816	0.047*

Table 4. Lang, 2007 yield and fiber quality by irrigation.

	Dry	Irrigated	P-Value
Seed Weight	2282	4335	<0.0001**
Lint Weight	869	1646	<0.0001**
Turnout	0.379	0.378	0.9337
Staple	34.56	36.88	0.0001**
Micronaire	5.34	4.61	<0.0001**
Strength	30.781	32.038	<0.0001
Length	1.079	1.150	<0.0001**
Uniformity	0.819	0.822	0.1081

Table 5. Lang, 2007 yield and fiber quality by variety.

	DP555BR	FM960B2R	P-Value
Seed Weight	3489	3128	0.0333*
Lint Weight	1386	1129	0.0006**
Turnout	0.396	0.361	0.0001**
Staple	35.13	36.31	0.0003**
Micronaire	4.97	4.99	0.7929
Strength	31.200	31.619	0.5739
Length	1.094	1.135	0.0001**
Uniformity	0.816	0.825	0.0001**

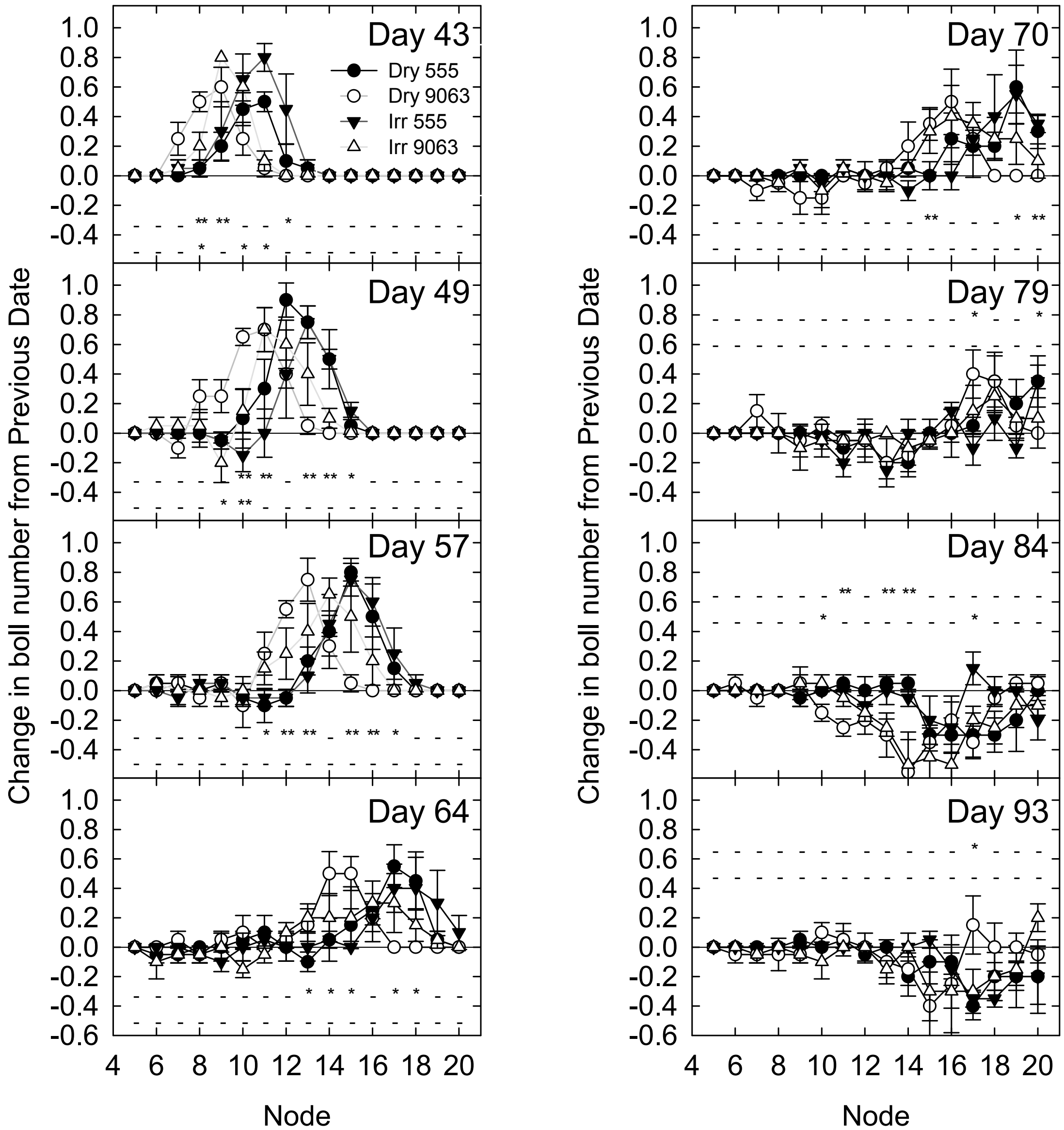

Figure 7. Change in first position boll number by node at each measurement date, showing the formation and loss of fruiting structures during the 2008 test. Error bars represent standard error of the mean for each treatment at each node.
* P < 0.05
** P < 0.01
- not significant.

Figure 7 shows the change in first position boll number by node at each measurement date in 2008. These graphs show the location of new fruiting structures throughout the growing season. The DP555 plots consistently produced more fruiting structures higher in the plant than the FiberMax varieties in both seasons, while the FiberMax plants produced more fruiting structures in the lower portion of the plant and shed more fruit above node 14. The highest levels of fruit shed for FM9063 in 2008 occurred between days 79 and 93, as shown in Figure 7.

Table 6. Lang, 2007 yield and fiber quality – interaction of variety and irrigation.

	Dry DP555	Dry FM960	Irrigated DP555	Irrigated FM960	P-Value Irr*Var
Seed Weight	2437	2126	4540	4130	0.757
Lint Weight	963	775	1808	1483	0.304
Turnout	0.394	0.363	0.398	0.359	0.251
Staple	33.75	35.38	36.50	37.25	0.128
Micronaire	5.34	5.35	4.60	4.63	0.930
Strength	30.063	31.500	32.338	31.738	0.178
Length	1.056	1.103	1.133	1.168	0.429
Uniformity	0.815	0.824	0.818	0.827	0.861

Discussion

There are several possible reasons for the difference in fiber quality between the two varieties, due to growth differences within the plant. As it was observed in the study, 555 had an increase of boll production at higher nodes, an increase in second position bolls, a decrease in first position bolls at the lower mainstem nodes, and decreased boll weight throughout the plant.

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