Cotton

Research and Extension Report 2015

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THE 2015 CROP YEAR IN REVIEW

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The 2015 production season was unique in many ways, as each year typically presents the state of Georgia with new challenges and opportunities. Georgia growers harvested an estimated 1,120,000 acres, the state's lowest harvested cotton acreage since 2009. Despite the lower acreage, the National Agriculture Statistics Service reports that Georgia remains the second-largest cotton-producing state in the union, preceded only by Texas. The conditions of the 2015 growing season were generally optimal, with the exception of abnormally excessive rainfall during boll opening and harvest, which caused significant harvest issues. Depressed cotton prices negatively affected the economics of production throughout 2015, and producers paid close attention to the costs of inputs and overall production. The 2015 growing season presented a first for cotton producers, as it was the first year that cotton with tolerance to the herbicides glyphosate, glufosinate, and dicamba was available to be planted commercially in Georgia. This marked the introduction of the XtendFlex cotton from Monsanto, and producers planted an estimated 200,000 acres with varieties having this trait, although the application of dicamba was not labeled for the growing season.

The most common challenges for growers in 2015 included thrips, nematodes, glyphosate-resistant Palmer amaranth, and boll rot and hardlock. The boll rot and hardlock was related to excessive rainfall received late in the growing season. Despite these and other challenges, many parts of Georgia produced higher than expected yields, resulting in a projected statewide average yield of 986 pounds per acre. Georgia is expected to produce over 2,500,000 bales during 2015, sustaining the state's commitment to cotton despite difficult economic times.

Although yields were variable across the state based on rainfall during the growing season and harvest, average statewide yields continue to rise. Over the past 15 years, yields in Georgia have increased by an average of 3.4 percent each year and by 50 percent during the entire period, which is a true testament to Georgia's growers, their commitment to cotton, and the release of superior varieties. Modern varieties are currently being released into the market rapidly, but due to increased competition and industry advancements, variety selection remains a very important and costly issue. That said, many new varieties performed very well for Georgia growers in 2015.

The 2015 cotton acreage in Georgia was predominately comprised of Deltapine varieties (63.44%), Phytogen varieties (24.30%), Stoneville (7.01%), and FiberMax varieties (2.51%) (http://www.ams.usda.gov/AMSv1.0/).

The quality of the 2015 crop was significantly affected by weather conditions during harvest, however, the overall outcome should be considered a success when considering the challenges producers faced in 2015. Of the bales classed, 0.1 percent were short staple (<34) and 17.3 percent were high mic (>4.9). Average staple was slightly higher than the previous two years.

Average micronaire has remained around 4.7 over the past five years and remained at that level in 2015. Fiber length uniformity remained high in 2015. Most noticeably, bark incidence has been subsequently lower in all three years following the significant issues during 2012.

Table 1. Fiber Quality of Bales Classed by December 1st at the Macon USDA Classing Office, 2008-2015.

	Color Grade 31/41 or better (% of crop)	Bark/ Grass/ Prep (% of crop)	Staple (32nds)	Strength (g/tex)	Mic	Uniformity
2008	25 / 93	all < 1.0	34	28.7	4.6	80.2
2009	26 / 96	all < 1.0	35	28.8	4.5	80.3
2010	50 / 90	all < 1.0	35	29.9	4.8	81.0
2011	38 / 84	3.0 / <1 / 1.0	36	29.6	4.6	81.7
2012	46 / 91	12.4 / <1 / <1	36	29.1	4.7	81.5
2013	57 / 98	5.7 / <1 / <1	35.9	29.7	4.8	81.7
2014	62 / 87	3.4 / <1 / <1	35.6	29.0	4.7	81.3
2015	16 / 54	2.3 / <1 / 5.2	36.0	29.0	4.7	81.6

Bales classed short staple (<34) and high mic (>4.9)
2008: 20% & 21% 2009: 22% & 20% 2010: 4% & 9% 2011: 2.8% & 8.8%
2012: 1.4% & 20.5% 2013: 1.1% & 30.1% 2014:0% & 18.1% 2015: 0.1% &17.3%

Source: http://www.ams.usda.gov/AMSv1.0/

2015 COTTON OVT VARIETY TRIALS

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Introduction

The University of Georgia's 2015 Cotton Variety Trials (OVT) were conducted at five locations across Georgia, spanning the cotton belt from southwest to northeast Georgia. Irrigated trials were conducted on-farm in Decatur County and at UGA research and education centers in Midville, Plains, and Tifton. Dryland trials were conducted at UGA research and education centers in Athens, Midville, Plains, and Tifton. Performance data in these tables, combined with data from previous years, should assist growers with variety selection, one of the most important — if not most important — decisions in an economically viable cotton production plan. Data collected from the University of Georgia Variety Testing Cotton Program can be found at the Statewide Variety Testing Website: www.swvt.uga.edu. The data is also published in the UGA Agricultural Experiment Station Annual Publication 104-7, January 2016.

Materials and Methods

The University of Georgia conducts Official Cotton Variety (OVT) and Strain (OST) trials across Georgia to provide growers, Private Industry, Extension Specialist, and County Agents with performance data to help in selecting high yielding adapted varieties. Data from the OVT assists the private seed companies to assess the fit of their products in Georgia. The University of Georgia cotton OVT is conducted by John D. Gassett, Program Director of Cotton OVT in Griffin, GA, along with Henry Jordan Jr., Research Professional III in Griffin, GA, Dustin Dunn, Research Professional III in Tifton, GA, and J. LaDon Day of the Crop and Soil Science Department in Griffin, GA. The OVT is split into released variety and strain trials with placement of varieties or strains into the particular trial chosen by its owner. Trials are separated by maturity. Irrigated OVT trials are conducted at Bainbridge, Midville, Plains, and Tifton, while dryland OVTs are conducted at Athens, Midville, Plains, and Tifton. Varieties placed into the OVT are included in eight trials per year, giving a fair sized data set with which to evaluate variety performance. The strains trials are irrigated and conducted at Midville, Plains, and Tifton. Trials consist of 4-replicate, randomized complete block designs. An accepted and common management system is employed at each location for agronomic and pest management, but transgenic cultivars are not produced according to their intended pest management system(s). A random quality sample was taken on the picker during harvest and ginned to measure lint fraction on all plots. All fiber samples were submitted to the USDA Classing Office in Macon, GA, for HVI analyses. Trials were picked with a state-of-the-art harvest system composed of an International IH 1822 picker fitted with weigh baskets and suspended from load cells. This system allows one person to harvest yield trials where the established bag-and-weigh approach required eight people or more. The electronic weigh system allowed for timely harvest of yield trials. Data from all trials and combined analyses over locations and years are reported as soon as fiber data are available from the test lab in Adobe PDF and Excel formats on the UGA Cotton Team Website maintained at www.ugacotton.com. The data is also available at the Statewide Variety Testing Website: www.swvt.uga.edu.

Results and Discussion

Georgia agronomic producers were faced with highly variable weather conditions across the state in 2015 for planting. For much of the state, soil moisture was adequate for planting, but spring plantings of cotton and peanuts were delayed due to excessive rainfall amounts early in the spring, and the lack thereof for many in the Coastal Plain in May. Low soil temperatures from cool nights and lower-than-normal temperatures during the day were also concerning. Irrigation was needed for many producers in May. Harvesting was also inhibited for many growers due to frequent precipitation events and wet soils.

Attapulgus and Midville were the only two locations out of five that did not receive the normal amount of rainfall. Athens, Plains, and Tifton received 41, 9, and 10 percent more rainfall than normal, respectively.

Crop maturity progressed above the five-year average, while harvest conditions were hampered due to wet weather conditions in 2015. Cotton producers seeded 1.13 million acres in Georgia, an 18% decrease from last year.

In Georgia, cotton yielded 986 pounds per acre this year, a 9 percent increase from last year, and a total production of 2.3 million bales or 11 percent less than the previous year.

Among varieties in the Dryland Earlier Maturity Trials, BRS 335, DG CT 1415, DG 3385 B2XF, GA 2011124, DP 1522 B2XF, DP 1614 B2XF, MON 15R513B2XF, NG 3405 B2XF, PHY 312 WRF, PHY 444 WRF, PHY 487 WRF, PHY 499 WRF, and SSG AU 222 stand out as varieties with high yield and relative yield stability in the dryland trials averaged over four locations (Table 1). When summarized over two years and four locations PHY 333 WRF was the top performer, while four other varieties were above average (Table 2).

Among the best performing earlier maturing varieties produced under irrigation, CG 3475 B2XF, DG 3385 B2XF, DG CT14515, DP 1522 B2XF, GA 2011124, MON 15R513B2XF, PHY 312 WRF, PHY 333 WRF, PHY 444 WRF, and PHY 487 WRF were the top highest in yield when averaged over four locations (Table 3). PHY 333 WRF was the top yielding variety when averaged over two years and locations in the Irrigated Early Maturity Trials conducted at Bainbridge, Midville, Plains, and Tifton (Table 4). Four other varieties were above average in yield (Table 4).

The top yielding later maturity variety in the trial conducted without irrigation and averaged over four locations revealed the consistent performance of CG 3787 B2RF, CG 3885 B2XF, DP 1252 B2RF, DP 1454NR B2RF, DP 1538 B2XF, DP 1553 B2XF, DP 1555 B2RF, DP 1558 NR B2RF, PHY 444 WRF, PHY 495 W3RF, PHY 499 WRF, PHY 552 WRF, ST 51125GLT, and ST 6182GLT (Table 5). An additional single variety was above average in yield (Table 5). Varieties from All-Tex, Bayer, Georgia, Dow, Dyna-Gro, and Monsanto were high yielding performers among standard later maturing entries in the later maturity, non-irrigated trial (Table 6).

Under irrigation, there were fifteen varieties in the top significant group of the standard later maturing trials averaged over locations with CG 3787 B2RF, CG 3885 B2XF, DP 1252 B2RF, DP 1538 B2XF, DP 1553 B2XF, DP 1555 B2RF, DP 1558NR B2RF, DP 1646 B2XF, PHY 333 WRF, PHY 444 WRF, PHY 495 W3RF, PHY 499 WRF, PHY 552 WRF, ST 4946GLB2, and ST 5115GLT among the top yielding varieties (Table 7). Four other varieties were above average in lint yield (Table 7). Averaged over locations and two years, DP 1558NR B2RF is the significant front-runner, while eight other varieties were above average in yield (Table 8).

The Earlier Maturity and Later Maturity Strains Trials (OST) portend improved varieties for crop seasons 2016 and beyond. Varieties from All-Tex, Americot, Dow, and Georgia, were high yielding performers among standard earlier and later maturing entries in the strains trial (Table 9).

Quality fractions were obtained by sending samples to the USDA Classing Office in Macon, GA, for HVI analysis processing, and can be found in all of the aforementioned tables.

In summary, several new varieties described herein portend potentially higher yields and improved fiber packages available to Georgia growers.

Table 1. Yield Summary of Dryland Earlier Maturity Cotton Varieties, 2015

Variety	Athens	Midville	Plains	Tifton	4-Loc. Average	Lint	Unif. Index	Length	Strength	Mic.
	Lint Yield[a]									
	---- lb/acre ----					%	%	in	g/tex	units
DG CT14515	471 [3]	**780** [5]	**1101** [8]	**1435** [3]	**947** [1]	44.1	82.3	1.15	31.3	5.1
MON 15R513B2XF	**595** [1]	606 [19]	**1222** [1]	1351 [9]	**944** [2]	43.7	82.7	1.14	28.9	5.0
PHY 487 WRF	457 [4]	**842** [1]	**1066** [9T]	**1393** [5]	**940** [3]	43.8	81.6	1.08	28.2	5.3
PHY 499 WRF	**563** [2]	**793** [4]	1030 [10]	1363 [8]	**938** [4]	45.0	82.8	1.09	30.9	5.0
SSG AU 222	374 [13]	**777** [6]	**1180** [3]	1388 [6]	**930** [5]	42.4	82.4	1.13	29.9	4.9
PHY 444 WRF	293 [19]	**711** [12]	**1066** [9T]	**1609** [1]	**920** [6]	45.8	83.4	1.16	30.5	4.3
DP 1522 B2XF	383 [11]	**812** [2]	**1104** [7]	1322 [10]	**905** [7]	44.0	82.0	1.13	29.7	5.0
PHY 312 WRF	398 [9]	**744** [8]	925 [15]	**1510** [2]	**894** [8]	45.1	83.1	1.13	30.2	4.8
DG 3385 B2XF	262 [20]	**762** [7]	**1191** [2]	1320 [11]	**884** [9T]	45.0	81.8	1.10	27.1	5.0
DP 1614 B2XF	404 [7]	669 [15T]	**1166** [4]	1298 [14]	**884** [9T]	45.2	83.6	1.16	30.3	5.1
BRS 335	448 [5]	**807** [3]	1028 [11]	1254 [17]	**884** [9T]	42.1	81.9	1.11	29.9	4.8
GA 2011124	376 [12]	**719** [11]	976 [14]	**1409** [4]	**870** [10]	44.7	81.2	1.11	29.5	5.0
NG 3405 B2XF	395 [10]	683 [14]	**1115** [5]	1257 [16]	**863** [11]	44.4	81.6	1.08	26.9	4.9
PHY 333 WRF	366 [15]	**724** [10]	983 [13]	1266 [15]	**835** [12]	44.9	83.1	1.13	29.8	4.7
PHY 339 WRF	401 [8]	706 [13]	882 [16]	1303 [13]	823 [13]	43.7	83.3	1.14	30.9	4.6
CG 3475 B2XF	363 [16]	589 [20]	1014 [12]	1306 [12]	818 [14]	42.4	82.7	1.12	30.4	4.8
GA 2010102	371 [14]	669 [15T]	844 [17]	1368 [7]	813 [15]	44.5	82.5	1.12	29.9	5.1
SSG HQ 212 CT	446 [6]	**742** [9]	796 [19]	1179 [18]	791 [16]	41.3	81.7	1.10	30.6	5.1
NG 3406 B2XF	249 [21]	613 [17]	**1105** [6]	1076 [20]	761 [17]	44.0	82.1	1.10	28.3	4.8
SSG HQ 210 CT	332 [17]	632 [16]	745 [20]	1109 [19]	704 [18]	39.8	81.7	1.09	30.3	4.9
GA 2009100	304 [18]	611 [18]	797 [18]	995 [21]	677 [19]	40.9	83.3	1.17	32.7	4.4
Average	393	714	1016	1310	858	43.7	82.4	1.12	29.8	4.9
LSD 0.10	116	134	166	219	115	1.2	0.9	0.03	1.3	0.2
CV %	25.1	15.9	13.9	14.1	16.1	2.6	1.2	2.4	3.5	4.7

[a] Superscripts indicate ranking at that location.

Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 2. Two-Year Summary of Dryland Earlier Maturity Cotton Varieties at Four Locations[a], 2014-2015

Variety	Lint Yield	Lint	Uniformity Index	Length	Strength	Micronaire
	lb/acre	%	%	inches	g/tex	units
PHY 499 WRF	**1140**	44.4	83.0	1.10	31.2	4.8
PHY 444 WRF	**1127**	45.0	83.4	1.19	30.9	4.1
PHY 487 WRF	**1115**	42.9	81.8	1.09	28.7	4.9
PHY 333 WRF	**1102**	44.5	83.2	1.14	30.0	4.5
SSG AU 222	**1093**	42.2	82.6	1.15	30.4	4.6
BRS 335	1010	41.4	82.3	1.13	30.3	4.6
GA 2010102	912	41.9	83.0	1.14	32.5	5.0
SSG HQ 210 CT	911	39.4	81.9	1.10	30.7	4.7
GA 2009100	867	40.0	83.2	1.16	32.9	4.7
Average	1031	42.4	82.7	1.13	30.8	4.7
LSD 0.10	62	0.5	0.5	0.01	0.7	N.S.[1]
CV%	14.6	2.8	1.0	2.0	3.8	5.4

[a] Athens, Midville, Plains, and Tifton.

1. The F-test indicated no statistical differences at the alpha = 0.10 probability level; therefore, an LSD value was not calculated.

Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 3. Yield Summary of Earlier Maturity Cotton Varieties, 2015, Irrigated

Variety	Lint Yield[a] Bainbridge	Midville	Plains	Tifton	4-Loc. Average	Lint	Unif. Index	Length	Strength	Mic.
	---------- lb/acre ----------					%	%	in	g/tex	units
DP 1522 B2XF	1725 [9]	**1904** [5]	**1620** [1]	**1697** [3]	**1737** [1]	43.2	84.2	1.17	31.5	4.8
PHY 333 WRF	**1955** [1]	**1967** [3]	1421 [5]	1510 [11]	**1714** [2]	44.1	84.0	1.19	32.0	4.3
PHY 487 WRF	1771 [6]	**1950** [4]	1418 [6]	**1693** [4]	**1708** [3]	43.5	82.4	1.11	29.6	4.8
PHY 444 WRF	**1865** [2]	1802 [9]	1368 [10]	**1760** [2]	**1699** [4]	45.5	84.7	1.27	32.2	4.1
GA 2011124	1679 [11]	**1850** [8]	**1600** [2]	1539 [9]	**1667** [5]	43.6	83.5	1.16	31.8	4.8
PHY 312 WRF	**1804** [4]	**1983** [2]	1280 [18]	1578 [7]	**1661** [6]	43.8	84.7	1.20	32.7	4.4
DG CT14515	1524 [15]	**2039** [1]	1299 [19]	**1660** [5]	**1631** [7]	44.2	83.6	1.19	32.7	4.8
CG 3475 B2XF	**1814** [3]	1697 [17]	**1577** [3]	1341 [16]	**1607** [8]	41.8	83.7	1.16	32.0	4.8
DG 3385 B2XF	**1789** [5]	1760 [13]	1371 [9]	1481 [12]	**1600** [9]	43.6	84.2	1.16	30.0	4.7
MON 15R513B2XF	1759 [8]	1777 [12]	**1528** [4]	1312 [17]	**1594** [10]	43.5	84.4	1.19	31.2	4.9
NG 3405 B2XF	1681 [10]	1800 [10T]	1378 [8]	1383 [15]	1560 [11]	44.0	82.8	1.12	28.0	4.5
PHY 499 WRF	1641 [13]	1702 [15]	1413 [7]	1453 [13]	1553 [12]	44.5	84.3	1.16	33.4	4.6
PHY 339 WRF	1568 [14]	**1863** [7]	1239 [19]	1515 [10T]	1546 [13]	43.1	83.8	1.19	32.1	4.2
BRS 335	1645 [12]	1646 [19]	1314 [13]	1558 [8]	1540 [14]	41.5	83.5	1.17	32.9	4.5
SSG AU 222	1480 [17]	1734 [14]	1320 [12]	**1606** [6]	1535 [15]	41.6	84.0	1.22	31.8	4.5
NG 3406 B2XF	1764 [7]	1671 [18]	1353 [11]	1270 [19]	1515 [16]	42.9	83.8	1.15	30.0	4.7
GA 2010102	1189 [21]	1800 [10T]	1283 [17]	**1766** [1]	1510 [17]	42.8	83.6	1.15	31.5	4.8
DP 1614 B2XF	1486 [16]	1701 [16]	1312 [14]	1515 [10T]	1504 [18]	45.5	84.5	1.21	31.6	4.9
SSG HQ 210 CT	1376 [19]	1779 [11]	1066 [20]	1430 [14]	1413 [19]	40.2	82.9	1.14	31.9	4.8
SSG HQ 212 CT	1338 [20]	**1864** [6]	1021 [21]	1275 [18]	1374 [20]	41.3	83.2	1.14	32.1	4.8
GA 2009100	1396 [18]	1397 [20]	1303 [15]	1111 [20]	1302 [21]	42.2	84.2	1.21	32.8	4.1
Average	1631	1795	1356	1498	1570	43.2	83.8	1.17	31.6	4.6
LSD 0.10	178	193	160	174	167	0.8	0.6	0.02	1.0	0.2
CV %	9.2	9.1	10	9.8	9.5	1.5	0.8	1.55	3.6	4.1

[a] Superscripts indicate ranking at that location.

Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 4. Two-Year Summary of Earlier Maturity Cotton Varieties at Four Locations[a], 2014-2015, Irrigated

Variety	Lint Yield	Lint	Uniformity Index	Length	Strength	Micronaire
	lb/acre	%	%	inches	g/tex	units
PHY 333 WRF	**1781**	43.3	83.5	1.18	31.0	4.2
PHY 444 WRF	**1752**	44.7	84.4	1.25	32.1	3.9
PHY 487 WRF	**1724**	42.7	82.4	1.13	30.0	4.4
PHY 499 WRF	1701	43.9	83.9	1.15	32.4	4.6
SSG AU 222	1653	41.8	83.7	1.20	31.3	4.3
GA 2010102	1584	41.7	83.6	1.16	32.5	4.6
SSG HQ 210 CT	1554	40.4	82.8	1.14	31.7	4.5
BRS 335	1550	41.1	83.0	1.17	32.5	4.2
GA 2009100	1404	41.1	83.6	1.18	32.4	4.3
Average	1633	42.3	83.4	1.17	31.8	4.3
LSD 0.10	64	0.3	0.5	0.01	N.S.[1]	N.S.
CV%	9.5	2.0	1.0	2.1	4.0	5.7

[a] Bainbridge, Midville, Plains, and Tifton.

1. The F-test indicated no statistical differences at the alpha = 0.10 probability level; therefore, an LSD value was not calculated.

Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 5. Yield Summary of Dryland Later Maturity Cotton Varieties, 2015

	Lint Yield[a]														
Variety	Athens		Midville		Plains		Tifton		4-Loc. Average		Lint	Unif. Index	Length	Strength	Mic.
	lb/acre										%	%	in	g/tex	units
DP 1553 B2XF	**969**	1	**711**	6	**1248**	2	1733	13	**1165**	1	45.5	83.4	1.16	29.7	4.8
DP 1538 B2XF	599	17	**729**	5	**1232**	3	**2030**	2	**1148**	2	45.4	82.6	1.09	28.2	4.9
DP 1646 B2XF	602	16	640	14	**1332**	1	**1848**	7	**1106**	3	45.7	83.2	1.21	29.2	4.8
CG 3885 B2XF	734	8	**690**	8	**1229**	4	1712	18	**1091**	4	44.9	83.1	1.12	28.7	4.9
PHY 444 WRF	535	21	**759**	2	963	24	**2038**	1	**1074**	5T	45.9	83.8	1.20	31.4	4.6
DP 1555 B2RF	793	5	648	12	**1135**	7	1718	17	**1074**	5T	45.2	82.4	1.15	32.0	4.9
DP 1252 B2RF	714	11	669	10	1005	19	**1905**	5	**1073**	6	45.8	83.6	1.14	29.6	5.0
CG 3787 B2RF	713	12	618	20	1013	17	**1945**	3	**1072**	7	45.0	82.5	1.12	29.3	4.9
PHY 552 WRF	760	7	515	28	1086	9	**1919**	4	**1070**	8	44.6	83.8	1.14	32.0	4.7
PHY 499 WRF	797	3	**737**	3	950	25	1743	12	**1057**	9T	44.5	83.1	1.13	32.3	4.7
ST 6182GLT	732	9	644	13	**1131**	8	1723	15	**1057**	9T	47.4	83.3	1.14	29.4	4.8
PHY 495 W3RF	796	4	619	19T	968	23	**1827**	9	**1052**	10	44.1	82.9	1.09	30.9	4.8
DP 1454NR B2RF	**911**	2	632	16	937	28	1720	16	**1050**	11	44.6	82.9	1.13	30.8	4.9
ST 5115GLT	728	10	588	26T	1074	11	1775	10	**1041**	12	42.6	81.6	1.10	30.7	4.7
DP 1558NR B2RF	787	6	**682**	9	1079	10	1611	20	**1040**	13	44.3	83.4	1.17	32.5	5.1
NG 5007 B2XF	583	18	**776**	1	1063	13T	1595	21	1004	14	44.1	82.9	1.15	28.6	4.7
GA 2009037	457	28	**700**	7	1002	20	**1832**	8	998	15	43.5	82.0	1.15	30.2	5.0
ST 6448GLB2	679	13	591	25	941	26	1731	14	986	16	42.1	82.5	1.19	29.9	4.8
NG 3405 B2XF	488	25	627	18	1023	16	1768	11	977	17T	43.1	81.8	1.09	27.1	4.7
GA 2010076	630	14	630	17	1063	13T	1585	23	977	17T	42.1	83.4	1.17	33.3	5.1
PHY 333 WRF	563	19	596	22	823	29	**1904**	6	972	18	45.1	82.2	1.13	29.0	4.7
DG CT15622	626	15	588	26T	1048	14	1581	24	961	19	44.0	83.7	1.15	29.9	4.7
DP 1639 B2XF	494	24	655	11	**1186**	5	1458	30	948	20	44.8	84.1	1.14	31.8	5.1
ST 4946GLB2	450	30	637	15	1010	18	1685	19	946	21	43.5	83.0	1.12	30.3	4.8
BX 1638GLT	454	29	**730**	4	1042	15	1516	27	936	22	44.3	82.8	1.17	32.2	4.8
NG 3406 B2XF	442	31	619	19T	**1165**	6	1502	29	932	23	44.3	82.8	1.12	28.1	4.7
GA 2010019	495	23	606	21	977	22	1510	28	897	24	43.1	82.7	1.15	30.6	4.6
BRS 286	465	27	595	23	939	27	1557	26	889	25	41.3	83.1	1.14	32.2	4.9
GA 230	532	22	497	29	1067	12	1379	32	869	26	41.7	83.3	1.22	31.3	4.7
GA 2009100	483	26	544	27	991	21	1434	31	863	27	42.7	83.1	1.17	33.1	4.4
BRS 293	551	20	593	24	589	31	1588	22	830	28	41.2	82.7	1.12	33.3	5.2
ST 4747GLB2	437	32	462	30	759	30	1560	25	804	29	43.1	82.8	1.17	29.6	4.8
Average	625		635		1033		1701		999		44	82.9	1.14	30.5	4.8
LSD 0.10	167		100		201		258		143		1.1	0.8	0.02	1.2	0.2
CV %	22.7		13.4		14.2		12.9		15.7		1.1	2.2	2.17	3.6	4.0

[a] Superscripts indicate ranking at that location.

Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 6. Two-Year Summary of Dryland Later Maturity Cotton Varieties at Four Locations[a], 2014-2015

Variety	Lint Yield	Lint	Uniformity Index	Length	Strength	Micronaire
	lb/acre	%	%	inches	g/tex	units
PHY 499 WRF	**1256**	44.2	83.2	1.13	32.3	4.7
PHY 333 WRF	**1249**	44.1	82.7	1.16	29.5	4.4
CG 3787 B2RF	**1240**	44.6	82.8	1.14	29.4	4.7
ST 4946GLB2	**1217**	42.6	83.2	1.13	31.0	4.6
PHY 495 W3RF	**1204**	43.6	83.2	1.11	31.4	4.6
DP 1454NR B2RF	**1171**	44.0	82.5	1.12	30.1	4.8
DP 1558NR B2RF	**1162**	44.1	83.1	1.15	32.4	5.0
GA 2010076	**1157**	41.3	83.4	1.17	33.0	4.9
ST 6448GLB2	**1143**	41.5	82.3	1.19	29.9	4.6
DP 1555 B2RF	**1139**	45.1	82.5	1.15	31.8	4.7
DP 1252 B2RF	**1128**	45.5	83.8	1.14	29.7	4.9
ST 6182GLT	**1115**	47.6	83.0	1.15	29.6	4.7
GA 2010019	**1078**	42.3	82.8	1.15	30.7	4.5
ST 4747GLB2	**1072**	42.1	82.3	1.18	29.6	4.5
GA 230	**1025**	40.6	83.0	1.22	31.3	4.4
GA 2009100	**977**	40.7	82.8	1.17	32.7	4.6
Average	1146	43.4	82.9	1.15	30.9	4.7
LSD 0.10	N.S.[1]	0.3	0.7	0.02	0.6	0.1
CV%	13.5	1.8	1.2	1.98	3.5	3.9

[a] Athens, Midville, Plains, and Tifton.

1. The F-test indicated no statistical differences at the alpha = 0.10 probability level; therefore, an LSD value was not calculated.

Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 7. Yield Summary of Later Maturity Cotton Varieties, 2015, Irrigated

	Lint Yield[a]									
Variety	Bainbridge	Midville	Plains	Tifton	4-Loc. Average	Lint	Unif. Index	Length	Strength	Mic.
	---------------------------- lb/acre	----------------------------				%	%	in	g/tex	units
DP 1558NR B2RF	**1991** [2]	1874 [4]	1430 [12]	**1658** [2]	**1738** [1]	44.6	84.3	1.19	32.6	4.9
DP 1646 B2XF	1682 [14]	**2139** [1]	1419 [13]	**1664** [1]	**1726** [2]	46.4	84.5	1.25	30.1	4.5
PHY 333 WRF	**2166** [1]	1683 [16]	1280 [22]	**1517** [10]	**1661** [3]	44.1	83.7	1.19	31.4	4.4
CG 3885 B2XF	1826 [7]	1745 [12]	**1697** [1]	1371 [20]	**1660** [4]	44.4	83.8	1.16	30.0	4.6
DP 1538 B2XF	1757 [8]	1773 [10]	**1608** [4]	1381 [19]	**1630** [5]	45.0	83.4	1.12	29.2	4.7
ST 4946GLB2	1681 [15T]	2083 [2]	1270 [23T]	**1482** [11T]	**1629** [6]	42.2	84.0	1.16	32.0	4.7
PHY 552 WRF	1654 [17]	2005 [3]	1370 [18]	**1482** [11T]	**1628** [7]	44.6	84.6	1.18	33.0	4.4
CG 3787 B2RF	1542 [23]	1861 [5]	1469 [9]	**1597** [4]	**1617** [8]	44.0	83.8	1.16	30.2	4.7
PHY 495 W3RF	1830 [6]	1828 [7T]	1217 [27]	**1557** [5]	**1608** [9]	44.5	84.0	1.13	32.5	4.6
ST 5115GLT	1459 [28]	1853 [6T]	1518 [5]	**1532** [9]	**1591** [10]	41.5	82.9	1.15	31.2	4.3
DP 1252 B2RF	1607 [22]	1667 [17]	**1627** [3]	1412 [15]	**1578** [11]	45.5	83.9	1.16	29.9	4.7
PHY 444 WRF	1849 [5]	1619 [19]	1188 [29]	**1638** [3]	**1573** [12]	44.8	84.8	1.27	31.9	3.9
DP 1555 B2RF	1509 [24]	1734 [13]	1452 [10]	**1555** [6]	**1562** [13]	45.0	83.6	1.19	31.6	4.4
PHY 499 WRF	1735 [10]	1809 [8]	1270 [23T]	1429 [14]	**1561** [14]	44.1	84.2	1.15	32.3	4.6
DP 1553 B2XF	1728 [12]	1853 [6T]	1378 [16]	1280 [24]	**1560** [15]	44.3	83.9	1.19	30.2	4.5
GA 2010019	1620 [20]	1775 [9]	**1650** [2]	1174 [26]	1555 [16]	42.1	83.6	1.18	31.7	4.4
GA 2009037	1857 [4]	1577 [22]	1227 [25]	**1545** [7]	1551 [17]	42.1	82.9	1.18	31.2	4.6
ST 6182GLT	1448 [29]	1716 [14]	1488 [8]	**1533** [8]	1546 [18]	46.5	83.7	1.17	30.2	4.4
ST 6448GLB2	1622 [19]	1757 [11]	1372 [17]	1400 [17]	1538 [19]	41.9	82.6	1.20	31.2	4.5
NG 3406 B2XF	1730 [11]	1518 [26]	1451 [11]	1438 [13]	1534 [20]	43.3	83.8	1.16	30.2	4.6
DP 1639 B2XF	1635 [18]	1633 [18]	1501 [7]	1324 [22]	1523 [21]	45.8	84.7	1.15	31.7	4.8
BX 1638GLT	1656 [16]	1607 [20]	1385 [15]	1396 [18]	1511 [22]	43.2	83.4	1.19	32.1	4.4
GA 2010076	1610 [21]	1690 [15]	1296 [21]	1444 [12]	1510 [23T]	40.7	84.0	1.19	34.1	4.8
NG 5007 B2XF	1865 [3]	1574 [23]	1516 [6]	1086 [31]	1510 [23T]	44.2	83.2	1.18	29.6	4.5
NG 3405 B2XF	1693 [13]	1589 [21]	1363 [19]	1325 [21]	1493 [24]	43.4	82.7	1.13	28.6	4.5
ST 4747GLB2	1508 [25]	1828 [7T]	1308 [20]	1321 [23]	1491 [25]	42.0	83.6	1.21	31.0	4.5
DG CT15622	1748 [9]	1416 [29]	1417 [14]	1122 [29]	1426 [26]	43.1	84.5	1.20	30.8	4.5
GA 2009100	1681 [15T]	1449 [28]	1184 [30]	1110 [30]	1356 [27]	41.2	84.1	1.20	32.6	4.2
BRS 286	1234 [31]	1528 [25]	1233 [24]	1401 [16]	1349 [28]	40.2	83.0	1.14	32.3	4.5
GA 230	1485 [26]	1376 [30]	1209 [28]	1225 [25]	1324 [29]	40.9	83.4	1.23	32.1	4.4
DP 1454NR B2RF	1287 [30]	1564 [24]	1226 [26]	1138 [28]	1304 [30]	44.1	83.2	1.13	30.7	4.6
BRS 293	1460 [27]	1459 [27]	1090 [31]	1173 [27]	1295 [31]	40.4	83.7	1.16	33.4	4.9
Average	1661	1706	1378	1397	1536	43.4	83.7	1.18	31.3	4.5
LSD 0.10	258	180	170	196	178	1.1	0.7	0.02	1.0	0.2
CV %	13.2	9.0	10.5	11.9	11.3	2.1	0.9	2.1	3.7	5.2

[a] Superscripts indicate ranking at that location.

Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 8. Two-Year Summary of Later Maturity Cotton Varieties at Four Locations[a], 2014-2015, Irrigated

Variety	Lint Yield	Lint	Uniformity Index	Length	Strength	Micronaire
	lb/acre	%	%	inches	g/tex	units
DP 1558NR B2RF	**1903**	44.4	84.0	1.18	32.4	4.8
PHY 333 WRF	1790	43.6	83.5	1.19	31.0	4.3
ST 4946GLB2	1760	42.2	83.6	1.16	31.9	4.5
CG 3787 B2RF	1732	43.9	83.6	1.16	29.7	4.5
PHY 495 W3RF	1729	43.8	83.7	1.13	32.4	4.5
PHY 499 WRF	1722	43.4	83.9	1.16	31.7	4.5
ST 6182GLT	1720	46.5	83.3	1.16	30.0	4.3
DP 1252 B2RF	1715	45.6	83.7	1.15	29.6	4.6
DP 1555 B2RF	1671	44.9	83.5	1.19	32.1	4.4
ST 4747GLB2	1655	41.9	83.0	1.20	30.3	4.3
DP 1454NR B2RF	1631	43.8	83.0	1.13	30.3	4.6
ST 6448GLB2	1619	41.9	82.8	1.20	30.9	4.3
GA 2010019	1611	41.9	83.1	1.17	31.3	4.3
GA 2010076	1609	40.6	83.5	1.19	32.9	4.7
GA 2009100	1486	40.0	83.7	1.20	32.6	4.3
GA 230	1434	40.8	83.6	1.22	31.6	4.2
Average	1674	43.1	83.5	1.17	31.3	4.4
LSD 0.10	75	0.4	0.4	0.02	0.7	0.1
CV%	10.9	2.1	0.9	2.2	3.9	5.7

[a] Bainbridge, Midville, Plains, and Tifton.

Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 9. Yield Summary of Cotton Strains, 2015, Irrigated

Variety	Lint Yield[a] Midville	Plains	Tifton	3-Loc. Average	Lint	Unif. Index	Length	Strength	Mic.
	------ lb/acre ------				%	%	inches	g/tex	units
DG CT15426	**2183** [2]	**1978** [1]	**1522** [3]	**1894** [1]	46.5	83.1	1.16	29.6	4.6
DG CT15557	**2185** [1]	**1857** [2]	1235 [14]	**1759** [2]	45.5	83.1	1.15	29.2	4.7
GA 2011113	**2009** [5]	**1778** [6]	1458 [5]	**1748** [3]	45.0	83.4	1.18	31.8	4.7
AMDG-7824	**1987** [6]	**1821** [3]	1421 [7]	**1743** [4]	45.0	82.6	1.15	29.6	4.5
ATX CT 15634 B2RF	1837 [12]	1664 [8]	**1688** [1]	**1730** [5]	46.5	84.3	1.18	30.6	4.7
GA 2012141	1852 [10]	**1783** [5]	1479 [4]	1704 [6]	44.2	84.0	1.21	31.1	4.5
GA 2012082	1887 [9]	**1784** [4]	1436 [6]	1702 [7]	42.7	83.4	1.21	33.0	4.6
GA 2012050	1961 [8]	1657 [9]	1416 [8]	1678 [8]	42.3	84.3	1.17	34.4	4.7
GA 2012085	1759 [15]	1618 [10]	**1593** [2]	1657 [9]	44.8	84.1	1.17	32.7	4.8
GA 2012025	**2025** [3]	1531 [12]	1368 [9]	1642 [10]	43.3	83.6	1.20	33.2	4.6
ATX DGX12WSTR-755 B2RF	**1977** [7]	**1731** [7]	1184 [16]	1631 [11]	43.9	83.7	1.24	31.4	4.5
ATX CT 15445 B2RF	**2024** [4]	1518 [13]	1299 [11]	1614 [12]	43.7	84.7	1.20	33.5	4.4
NB502-38Y cv	1844 [11]	1509 [15]	1339 [10]	1564 [13]	43.5	84.0	1.24	31.6	4.5
DG CT14555	1804 [13]	1568 [11]	1250 [13]	1541 [14]	42.6	84.1	1.24	31.8	4.1
ATX CT 15444 B2XF	1773 [14]	1511 [14]	1274 [12]	1519 [15]	43.1	85.1	1.21	34.7	4.9
ATX CT 15425 B2XF	1616 [16]	1482 [16]	1230 [15]	1442 [16]	43.0	84.4	1.22	33.8	4.5
Average	1920	1674	1387	1660	44.1	83.9	1.19	32.0	4.6
LSD 0.10	211	253	185	168	1.2	0.8	0.02	1.1	0.2
CV %	9.2	12.7	11.2	11.1	1.7	1.0	2.03	3.5	4.4

[a] Superscripts indicate ranking at that location.

Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

BREEDING CULTIVARS AND GERMPLASM WITH ENHANCED YIELD AND QUALITY, 2015

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Introduction

The classical breeding component of the University of Georgia cotton improvement program works to develop germplasm with traits that can be used to meet the requirements of both producers and consumers. Higher and more stable yields combined with the fiber properties requested by the yarn and textile manufacturers are the goals for profitable production and processing to support the Georgia cotton industry. The objective of this report is to update progress made toward meeting these goals during the 2015 production season.

Materials and Methods

Our crosses mate elite University of Georgia breeding lines with promising germplasm and non-transgenic commercial cultivars to produce sets of half-sib families; 200 crosses this year. The F_2-bulk populations from crosses made in the previous year and advanced in our greenhouse in counter season 2014/2015 were visually evaluated for lint yield from within a field nursery for selection advance to the F_3. The first level of selection of the F_3 plants are decided by visual determination with more individuals selected from the best populations, fewer individuals from the better populations, and few and perhaps none from the poorer populations. If a segregation of a desirable and non-desirable class is evident in the poorer populations, individual desirable plants are selected from each of these populations. Of the approximately 1,000 selected F_3 plants, the plants with lint fractions less than 39% are discarded and then further selected on the basis of HVI fiber properties. Selections are advanced to F_4 progeny rows in Plains, GA, for evaluation in an unreplicated grid design (Modified Augmented Design) with the middle row of each odd-numbered row set (5, 7, or 9) of the trial assigned to the University of Georgia cultivar GA 230 with additional secondary check cultivars. The F_4 test is machine harvested and the seed-cotton yield of each F_4 progeny row is compared with the seed-cotton yield of the nearest row of GA 230, which is, in turn, modified depending on the distribution of the yield values across the test field. Further selections of the F_4 are based essentially on the fiber quality measures of length, strength, and fineness and on lint percentage to promote for testing in the F_5 preliminary yield trials (PTs). Separate, later-planted seed increase plots that are grown in isolation near Tifton, GA allow additional visual selection and hand harvest of seed-cotton to maintain genetic purity of the F_4, F_5, F_6, and elite generation experimental lines. Additional increases are planted at the University of Arizona's Maricopa Agriculture Center in Maricopa, AZ, to provide excellent quality seed for the field tests in the subsequent years. The four 2015 PTs were conducted at the Southwest Research and Education Center (SWREC) in Plains, GA. Each PT had thirty-four F_5 breeding lines and 2 commercial conventional checks (GA 230 and Deltapine DP 1252 B2RF) in a three-replicate, randomized complete block design for a total of 136 experimental entries. The Elite Trials (ET1 and ET2) were conducted at the University of Georgia Tifton campus, Tifton, GA (at the William Gibbs Research Farm, fields 04470 and

04471) and SWREC, Plains, GA (in fields 52/62). The ETs each consisted of 31 experimental entries higher than the 7th generation. The trials were planted in a four-replicate, randomized complete block design with GA 230, GA 2009100, UA 48, UA 222, and Red Texas as the five checks. Prior to machine harvest of all trials except the F_2 and F_4 generations, 25 unweathered, open bolls from the middle of the fruiting zone were harvested from each plot, and subsequently ginned on a 20-saw Porter Morrison and Son laboratory gin (Dennis Manufacturing Inc., Athens, TX) to determine lint percentage. Fiber samples of the PTs and ETs were submitted to Cotton Incorporated in Cary, NC, for HVI fiber analysis. The elite (material > F_7) germplasm lines with high potential were also tested in the 2015 Georgia Official Strains Trial (OST) and Official Variety Trials (OVTs) (Gasset et al., 2016).

Results and Discussion

Seven of our lines (GA 2011124, GA 2009100, and GA 2010102 with the earlier maturing varieties and GA 230, GA 2009100, GA 2009037, GA 2010019, and GA 2010076 with the later maturing varieties) were tested in the 2015 GA OVTs (Gassett et al., 2016). The following is a general synopsis of these lines with further details found in the Georgia 2015 Peanut, Cotton, and Tobacco Performance Tests (Gassett et al., 2016).

In the Earlier Maturity Trial, GA 2011124 was ranked 5th in the irrigated trial over all of the locations for lint yield out of 21 entries and not significantly different from the top yielding cultivar. In the dryland, it yielded 10th, again not significantly different than the top yielding cultivar. All of the entries that we entered had a good fiber quality package. GA 2010102 did not yield well and will not be placed in further trials of the SWVT. GA 2009100 did not yield well either, but it looks that may have been caused by an emergence difficulty. Producing high quality seed in Georgia is not easy, as we well know.

In the Later Maturity Trial, the five GA entries (GA 230, GA 2009100, GA 2009037, GA 2010019, and GA 2010076) ranked erratically overall, going from the middle to the bottom of the trial. GA 230 and GA 2009100 persist in showing solid fiber packages in the irrigated trial, but they did not yield well this year, likely due to poor seed vigor. We are working to alleviate this difficulty by looking into a seed cleaner that also separates the seed by density to eliminate the poorer seeds. GA 2009037 yielded 4th and 7th in Bainbridge and Tifton, respectively, and very poorly in Midville and Plains. GA 2010019 yielded 9th and 2nd in Midville and Plains, respectively, and poorly in Bainbridge and Tifton. Such a clear delineation was very interesting and may simply be a maturity difference between the two lines. GA 2010076 will not be continued in the SWVT.

Six lines were tested in the 2015 Georgia OSTs: GA 2011113, GA 2012025, GA 2012050, GA 2012082, GA 2012085, and GA 20121410. The entire group has excellent fiber packages. GA 2011113 was the best yielder of our material and ranked 3rd across the three locations (Midville, Plains, and Tifton) and not significantly less than the top entry. Our next best yielders GA 2012050, GA 2012082, and GA 2012141 will also be promoted to the 2016 GA OVTs.

The 2015 ET1 and ET2 trials tested all the core lines and the remaining GA 2013 series mixed together (Tables 1, 2, & 3). The 2015 ET1 trial had location by entry interaction in yield (Table 1), so the individual location analyses were also reported (Table 2). At this point in time, only the Tifton fiber quality has returned from the fiber laboratory for any of the yield trials. The selection protocol is generally based on lint yield; if there was not environment by entry interaction found then the top yielders that were not significantly different were taken along with a few lines that were close to the cut-off, and if there was an interaction, then those top yielders of the individual locations were taken along with a few lines that were near the cut-off. GA 2011004 showed an extremely high lint % that we will be using in our crossing program with other lines that have excellent fiber quality. We expect that line to greatly enhance the lint percent of our upcoming lines in the future.

From the four 2015 PTs, 34 lines were preliminarily selected for testing in the 2016 AT1 trial based primarily on lint yield as compared to checks. We are awaiting the data from the Cotton Fiber Lab to further our selection strength. As we look to develop a cultivar better than our GA 230, the main components of selection within these populations are higher lint percent; fiber quality such as fiber length, fiber strength, and micronaire; and lint yield, the primary factor.

Based on lint yield comparisons (again we are awaiting the fiber quality measures to further our selection strength), 197 F_4 progenies were selected for placement in the 2016 PTs, more than we have normally had in total. Thirty-four populations from the 2015 F_2 nursery were selected for placement in the 2016 F_3 nursery for single plant selections.

Fifty F_1 crosses were sent to the USDA-ARS Cotton Winter Nursery in Costa Rica for selfing to the F_2 generation and were lost this first year of their existence. Our crosses that were placed in our greenhouse for generational advance as a backup will be placed in a 2016 F_2 nursery to determine the suitability of the germplasm populations to be further tested.

Table 1. Results of 2015 Elite (>F_7) Trial 1 Combined Location Analysis in Lint Yield and Lint Percent.

Elite Trial 1	combined locations		
	Lint Yield		Lint
Entry	lb/acre	rank	%
GA 2011004	1125	1	**44.4**
GA 2012050	1124	2	40.8
GA 2010079	1107	3	40.7
GA 2013055	1103	4	40.7
GA 2013025	1079	5	42.7
GA 2011113	1063	6	41.8
GA 2013113	1055	7	41.1
GA 2012134	1047	8	41.3
GA 2008016	1037	9	38.3
UA 48	1034	10	38.6
UA 222	1030	11	40.2
GA 2013021	1013	12	41.2
GA 2010074	1008	13	39.8
GA 2011042	1006	14	41.3
GA 2012083	995	15	39.0
GA 2012016	993	16	39.1
GA 2012038	991	17	41.5
GA 2012026	986	18	40.6
GA 2009037	986	19	40.6
GA 2013132	980	20	40.9
GA 2010019	978	21	40.6
GA 2013089	967	22	42.3
GA 2007095	959	23	39.2
GA 2013031	957	24	41.8
GA 2013013	953	25	40.5
GA 2009100	948	26	40.4
GA 2012046	941	27	39.8
GA 2013081	935	28	39.5
GA 2013001	919	29	41.2
GA 2013062	914	30	40.9
GA 2013116	908	31	41.0
GA 2013052	905	32	40.3
GA 230	850	33	39.2
GA 2013134	843	34	39.4
GA 2013111	821	35	38.7
Red Texas	621	36	34.9
$LSD_{0.10}$			0.80
Cultivar by location interaction	*		ns

When location by entry interaction is significant, the locations cannot be combined to compare for significant differences: **NS (no significance), † (10%), * (5%), ** (1%), & *** (0.1%).**
The bold type indicates the measures that are not significantly different from the best when the location data is properly pooled.

GA 230, GA 2009100, UA 48, UA 222, and Red Texas are check varieties for comparison purposes.

Table 2. Results of 2015 Elite (>F_7) Trial 1, Individual Location Analysis**.**

Elite Trial 1	-------- -------- -------- Tifton -------- -------- --------						------- Plains -------	
	Lint Yield	Lint	UHM	UI	Strength	Micronaire	Lint Yield	Lint
Entry	lb/acre	%	inches	%	gm/tex		lb/acre	%
GA 2011004	**1021**	**45.0**	1.14	**84.5**	33.1	**5.19**	**1249**	**43.86**
GA 2012050	**1154**	41.1	1.12	**84.9**	34.5	4.92	1078	40.37
GA 2010079	**1095**	41.2	1.13	83.6	31.3	**5.20**	**1149**	40.34
GA 2013055	921	40.9	**1.22**	84.4	33.9	4.72	**1238**	40.36
GA 2013025	**1106**	43.5	1.16	**85.2**	32.1	4.85	1003	41.99
GA 2011113	979	41.6	1.15	84.0	32.9	5.01	**1114**	41.81
GA 2013113	969	41.4	1.14	83.4	29.6	**5.20**	**1143**	40.65
GA 2012134	**1051**	41.9	1.15	**84.9**	31.1	4.96	1029	40.53
GA 2008016	969	38.3	1.15	83.9	33.8	5.12	**1115**	38.22
UA 48	954	39.1	**1.22**	**85.0**	**36.0**	5.16	1083	37.98
UA 222	**1121**	40.2	1.12	83.6	30.8	5.01	959	40.31
GA 2013021	963	42.1	1.13	**85.0**	31.3	4.89	1082	40.25
GA 2010074	904	39.6	1.14	84.0	32.8	5.07	**1115**	40.06
GA 2011042	833	41.4	1.13	**84.5**	32.5	4.99	**1181**	41.33
GA 2012083	876	39.6	1.15	84.3	33.6	4.84	1086	38.29
GA 2012016	757	37.9	1.18	**85.0**	**36.0**	4.92	**1217**	40.32
GA 2012038	841	41.9	1.11	83.4	32.3	**5.30**	**1168**	41.02
GA 2012026	889	41.1	1.09	**84.6**	32.9	**5.42**	**1109**	40.16
GA 2009037	869	40.5	1.12	83.4	29.7	5.00	**1112**	40.62
GA 2013132	882	41.1	**1.20**	**85.0**	34.0	4.89	**1101**	40.78
GA 2010019	831	40.9	1.12	84.1	30.9	4.92	**1108**	40.32
GA 2013089	912	42.1	1.18	**85.1**	32.4	4.98	994	42.43
GA 2007095	819	39.4	1.11	84.0	31.2	4.91	**1104**	38.98
GA 2013031	859	41.2	1.12	84.2	33.5	4.85	1084	42.49
GA 2013013	807	39.8	**1.22**	**85.4**	**34.8**	4.72	**1094**	41.25
GA 2009100	995	40.0	**1.20**	85.3	34.4	4.75	904	40.73
GA 2012046	869	40.7	1.14	84.4	32.8	4.94	1041	39.01
GA 2013081	937	39.6	1.16	**85.4**	33.1	4.96	962	39.44
GA 2013001	876	41.1	1.14	83.9	31.5	4.86	984	41.39
GA 2013062	744	41.6	1.16	84.0	32.7	4.78	1086	40.21
GA 2013116	854	41.1	1.13	83.8	33.2	4.77	940	41.02
GA 2013052	875	40.5	1.18	84.2	32.6	4.88	929	39.88
GA 230	692	39.1	**1.19**	84.9	32.8	4.78	1007	39.34
GA 2013134	863	39.6	**1.19**	**84.7**	33.3	4.92	802	39.10
GA 2013111	842	38.5	1.15	83.8	33.2	4.76	800	38.91
Red Texas	636	34.4	1.10	83.4	29.5	4.52	628	35.54
$LSD_{0.10}$	153	1.14	0.03	0.89	1.30	0.18	156	1.11

The bold type indicates the measures that are not significantly different from the best when the location data is properly pooled.

Exception: acceptable micronaire (mic) is a range, so significant differences (above 5.0) that are considered unacceptable are highlighted.

GA 230, GA 2009100, UA 48, UA 222, and Red Texas are check varieties for comparison purposes.

Table 3. Results of 2015 Elite (>F_7) Trial 2, Combined Location Analysis.

Elite Trial 2	combined locations		-------	------- Tifton -------		-------
	Lint Yield	Lint	UHM	UI	Strength	Micronaire
Entry	lb/acre	%	inches	%	gm/tex	
GA 2012141	**1277**	40.97	1.21	84.77	30.87	4.79
GA 2013098	**1275**	40.67	1.19	85.10	33.00	4.76
GA 2010102	**1267**	41.24	1.13	84.30	31.37	4.92
GA 2012082	**1261**	40.47	1.17	85.43	30.57	4.76
GA 2013024	**1247**	40.37	1.19	84.97	32.47	4.59
GA 2011156	**1245**	40.19	1.18	83.97	33.87	4.70
GA 2010070	**1224**	39.79	1.19	85.27	33.30	4.69
GA 2013027	**1213**	41.13	1.18	85.53	32.40	4.69
GA 2013019	**1211**	41.11	1.16	85.17	33.17	4.73
GA 2013114	**1206**	41.05	1.22	84.90	33.30	4.78
GA 2010076	**1202**	38.32	1.22	84.43	32.17	4.77
GA 2013041	**1191**	**41.51**	1.17	84.93	32.03	**5.23**
GA 2011124	**1165**	**42.36**	1.11	83.93	30.13	**5.28**
GA 2013084	**1162**	39.41	1.20	84.63	32.13	4.61
GA 2008016	**1161**	39.10	1.15	83.70	33.00	**5.18**
UA 222	1148	38.61	1.18	84.17	32.20	4.80
GA 2011108	1144	39.20	1.16	85.32	33.56	5.05
GA 2013054	1140	39.31	1.22	85.03	34.30	4.72
GA 2009037	1121	40.63	1.12	82.70	30.10	4.98
GA 2007095	1105	38.58	1.14	84.10	30.97	4.79
GA 2012085	1101	40.72	1.16	84.29	32.57	4.65
GA 2013112	1064	40.55	1.18	84.13	31.77	4.83
GA 2012044	1064	39.41	1.14	84.80	31.73	4.71
GA 2013070	1057	38.60	1.15	83.43	31.53	4.83
GA 2013125	1050	37.76	1.20	84.83	32.47	4.54
GA 2013057	1019	38.17	1.23	84.37	32.30	4.63
UA 48	1012	36.47	**1.27**	**86.53**	**37.13**	4.98
GA 2012025	1006	39.67	1.18	85.27	32.17	4.61
GA 230	997	38.99	1.20	84.90	32.90	4.79
GA 2009100	990	38.32	1.20	84.32	34.61	4.26
GA 2011005	979	38.57	1.17	85.03	32.00	4.57
GA 2013005	960	39.45	1.20	84.47	32.37	4.64
GA 2012047	952	38.12	1.19	85.00	35.37	5.04
GA 2012031	896	39.09	1.12	83.83	31.60	4.53
GA 2013133	821	39.16	**1.26**	85.20	34.23	4.82
Red Texas	748	35.04	1.14	83.00	29.60	4.48
LSD $_{0.10}$	116	1.00	0.03	0.79	1.34	0.17
Cultivar by location interaction	ns	ns				

When location by entry interaction is significant, the locations cannot be combined to compare for significant differences: **NS (no significance), † (10%), * (5%), ** (1%), & *** (0.1%).**

The bold type indicates the measures that are not significantly different from the best when the location data is properly pooled.

Exception: acceptable micronaire (mic) is a range, so significant differences above 5.0 that are considered unacceptable are highlighted.

GA 230, GA 2009100, UA 48, UA 222, and Red Texas are check varieties for comparison purposes.

Table 4. Results of 2015 Preliminary (F_5) Tests 1 and 2 in Tifton, GA.

Entry	Lint Yield lb/acre	Lint %	Entry	Lint Yield lb/acre	Lint %
GA 2015032	**1409**	42.16	GA 2015068	**1280**	42.01
GA 2015021	**1290**	**43.71**	GA 2015043	**1246**	41.00
GA 2015007	**1284**	40.87	GA 2015041	**1217**	41.23
GA 2015024	1273	42.85	GA 2015050	**1211**	40.31
GA 2015026	1263	42.45	GA 2015051	**1192**	40.50
GA 2015017	1222	40.83	GA 2015047	**1161**	42.25
GA 2015011	1219	42.25	GA 2015046	1157	**43.13**
GA 2015019	1213	40.47	GA 2015042	1157	38.30
GA 2015023	1212	41.57	GA 2015045	1150	39.88
GA 2015004	1207	41.82	GA 2015044	1137	39.87
GA 2015031	1199	41.68	GA 2015040	1128	40.82
GA 2015022	1194	40.61	GA 2015038	1125	40.71
GA 2015034	1193	41.36	GA 2015049	1121	41.77
GA 2015028	1192	40.03	DP 1252 B2RF	1107	**44.08**
GA 2015030	1177	41.12	GA 230	1107	40.25
GA 2015016	1174	40.96	GA 2015053	1091	40.51
GA 2015033	1172	**43.02**	GA 2015056	1077	37.58
GA 2015018	1160	41.82	GA 2015048	1054	**47.43**
DP 1252 B2RF	1156	**44.58**	GA 2015065	1052	40.16
GA 2015012	1142	40.94	GA 2015064	1049	38.66
GA 2015010	1130	41.65	GA 2015059	1045	37.31
GA 2015025	1125	42.75	GA 2015055	1036	37.60
GA 2015006	1119	40.81	GA 2015061	1025	38.41
GA 2015020	1116	42.57	GA 2015063	1022	38.90
GA 2015009	1097	41.03	GA 2015057	1019	38.08
GA 230	1062	39.85	GA 2015060	1008	39.60
GA 2015008	1030	42.26	GA 2015062	1005	39.29
GA 2015029	1023	37.57	GA 2015067	978	35.88
GA 2015027	1022	41.46	GA 2015058	924	37.52
GA 2015015	998	40.74	GA 2015039	919	41.98
GA 2015014	986	41.47	GA 2015066	911	37.49
GA 2015013	911	40.30	GA 2015052	904	39.88
GA 2015005	905	40.92	GA 2015054	789	37.92
$LSD_{0.10}$	131	1.65		122	1.12

The bold type indicates the measures that are not significantly different from the highest value. DP 1252 B2RF and GA 230 are check varieties for comparison purposes.

Table 5. Results of 2015 Preliminary (F_5) Tests 3 and 4 in Tifton, GA.

	Lint Yield	Lint		Lint Yield	Lint
Entry	lb/acre	%	Entry	lb/acre	%
GA 2015073	**1408**	41.19	GA 2015136	**1198**	39.92
GA 2015090	**1314**	42.20	GA 2015113	1070	42.05
GA 2015091	**1309**	41.67	GA 2015130	1068	37.38
GA 2015092	**1305**	40.92	GA 2015131	1042	38.06
GA 2015074	**1303**	40.77	GA 2015109	1025	40.36
GA 2015078	**1262**	42.72	GA 2015135	1007	39.86
GA 2015087	1222	40.71	GA 2015114	1004	36.99
GA 2015072	1221	42.21	GA 2015124	994	41.01
GA 2015083	1219	41.36	GA 2015120	993	38.39
GA 2015086	1207	39.97	GA 2015107	989	36.39
GA 2015088	1173	42.43	GA 2015115	984	40.42
GA 2015085	1170	42.09	DP 1252 B2RF	981	**43.14**
GA 2015084	1164	38.38	GA 2015127	981	38.52
GA 2015077	1151	42.04	GA 230	968	39.00
GA 230	1114	39.73	GA 2015134	957	37.93
GA 2015075	1110	41.01	GA 2015126	932	40.59
GA 2015076	1106	40.36	GA 2015133	920	36.78
GA 2015098	1095	38.06	GA 2015129	896	37.44
GA 2015094	1081	39.25	GA 2015125	895	37.89
GA 2015095	1075	39.67	GA 2015119	889	39.97
GA 2015079	1073	41.02	GA 2015108	885	40.36
GA 2015102	1065	38.55	GA 2015110	882	39.46
GA 2015099	1060	38.41	GA 2015121	877	38.42
GA 2015089	1053	39.21	GA 2015118	869	37.56
GA 2015097	1053	37.45	GA 2015132	868	37.01
GA 2015096	1024	37.53	GA 2015106	863	37.56
GA 2015081	993	38.31	GA 2015123	848	37.98
GA 2015093	987	38.74	GA 2015128	848	37.19
GA 2015080	984	41.99	GA 2015111	820	41.41
GA 2015100	977	38.87	GA 2015112	810	40.14
GA 2015101	948	41.61	GA 2015117	799	38.63
DP 1252 B2RF	920	**44.90**	GA 2015116	793	37.20
GA 2015082	903	39.03	GA 2015122	791	36.77
			GA 2015104	756	36.60
			GA 2015105	579	35.70
	157	1.24		108	1.06

The bold type indicates the measures that are not significantly different from the highest value.
DP 1252 B2RF and GA 230 are check varieties for comparison purposes.

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References

Gassett, J.D., J.L. Day, D.D. Dunn, H. Jordan Jr., and S.S. LaHue. 2016. Cotton. pp. 16-51. *In* Gassett, John D. et al. (eds.) Georgia: 2015 peanut, cotton, and tobacco performance tests. Ann. Pub. 104-7, The Georgia Agricultural Experiment Station/College of Agriculture and Environmental Sciences, The University of Georgia.

ASSESSING SEEDLING VIGOR TO QUANTIFY COTTON CULTIVAR RESPONSE TO EARLY SEASON WATER DEFICIT

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Introduction

Cotton seedling vigor characteristics have been evaluated many times in the past, but due to the constant release of new varieties coupled with new seed technologies, evaluation for characteristics for proper stand establishment is critical. Defining which of these newer cultivars is more drought tolerant requires a more definitive assessment of seedling growth characteristics in response to drought stress after emergence in the first few weeks of development and the rebound of these cultivars from drought stressed situations. Pace et al. (1999) have demonstrated that drought causes reductions in seedling shoot growth. This led to height, leaf area, number of nodes, and dry weights of the leaves and stems that were significantly impacted with reductions in each as compared to seedlings that were fully irrigated; however, root growth was not decreased in drought stressed seedlings. Drought stressed seedlings actually demonstrated taproot lengths that were significantly greater than seedlings that were well watered. Pace et al. (1999) observed no cultivar differences between a late maturing and early maturing cultivar; however, their observations did suggest that a common drought response in cotton seedlings was a lengthening of the taproot at the expense of root thickness to reach moisture deeper in the soil profile. Thus, the objective of this experiment was to attempt to identify cultivars tolerant to early season drought as determined from above ground growth characteristics.

Materials and Methods

Greenhouse experiments were conducted in 2015 at the Horticulture Department greenhouses in Athens, Georgia, utilizing a Split-Block Design with four replications. Commercial cotton cultivars planted in this study included FiberMax 1944GLB2, Deltapine 1050 B2RF, and Phytogen 499 WRF. Seed were planted at a 1-inch depth in 1.5 gallon pots. Promix BX planting medium was utilized with a bio fungicide to eliminate seedling disease issues. 18-5-12 Everris slow release nursery fertilizer was utilized to provide adequate soil fertility during the duration of the study. Irrigation treatments were arranged using a randomized block design. Three irrigation treatments were utilized: **T1**: well watered throughout the entire study, **T2:** irrigation was applied at planting to establish the seedling and then no additional water as applied for 21 days, **T3:** irrigation was applied at planting to establish the seedling and then no additional water was applied for 28 days. After each drought period was ended, each plant was well-watered for a 7-day recovery period, with plant growth analyzed before and after the recovery period. Plant growth was characterized by height, nodes, and number of squares present. After all plants were subjected to a recovery period (49 days after stand establishment), seedlings were destructively harvested to examine leaf area as well as stem, square, and leaf dry weights. The effect of irrigation treatment on plant growth was analyzed using a mixed effects ANOVA where block was a random effect and irrigation treatment was a fixed effect. Post-hoc analysis was conducted using Fisher's LSD ($\alpha = 0.05$).

Results and Discussion

Figure 1 demonstrates a substantial difference in leaf area between cultivars with Phytogen 499 having significantly more leaf area under well-watered conditions (T1) as compared to Deltapine

1050 and FiberMax 1944. Cultivar response in T2 and T3 was not significantly different. Deltapine 1050 T1 was not significantly different from T2 cultivars even though it was well-watered, indicating that DP1050 had lower vigor under well-watered conditions; however, it was also not affected by the water deficit conditions of T2. FiberMax 1944 T1 had significantly higher leaf area than its T2 counterpart, indicating a more significant leaf area decline in response to drought across the 21-day timeframe. Figure 2 demonstrates leaf dry matter with T1 Phytogen 499 having significantly more leaf dry matter than the other well-watered cultivars. For T2 and T3, cultivars were not observed to be significantly different in leaf dry matter. T1 1944 was not significantly different from the T2 or T3 cultivars in regard to leaf dry matter, whereas Deltapine 1050 T1 was significantly greater than T3 cultivars but not T2 cultivars. Square dry weights (Figure 3) were significantly greater for Phytogen 499 under well-watered conditions (T1) with no other significant differences between the cultivars and irrigation treatments. Stem dry weights were greatest for Phytogen 499 (T1) with no significant differences between the T2 and T3 cultivars (Figure 4). Square dry weights for T1 Deltapine 1050 and FiberMax 1944 were not significantly different from T2 Phytogen 499 or Deltapine 1050. Observations thusfar indicate that Phytogen 499 exhibited more vigorous early-season growth under well-watered conditions when compared to the other cultivars tested. Importantly as well, all three cultivars rebounded from the drought similarly, with Deltapine 1050 and Fibermax 1944 demonstrating similar reproductive dry weights regardless of irrigation, illustrating the stability of these cultivars across all treatments. These experiments will be repeated in 2016.

Table 1. Treatment ID and descriptions for Figures 1-4.

Irrigation Treatment ID	Irrigation Treatment Description	Cultivar ID	Cultivar Description
1	**Well watered**	**499**	**Phytogen 499 WRF**
2	**21 day drought**	**1050**	**Deltapine 1050 B2RF**
3	**28 day drought**	**1944**	**FiberMax 1944GLB2**

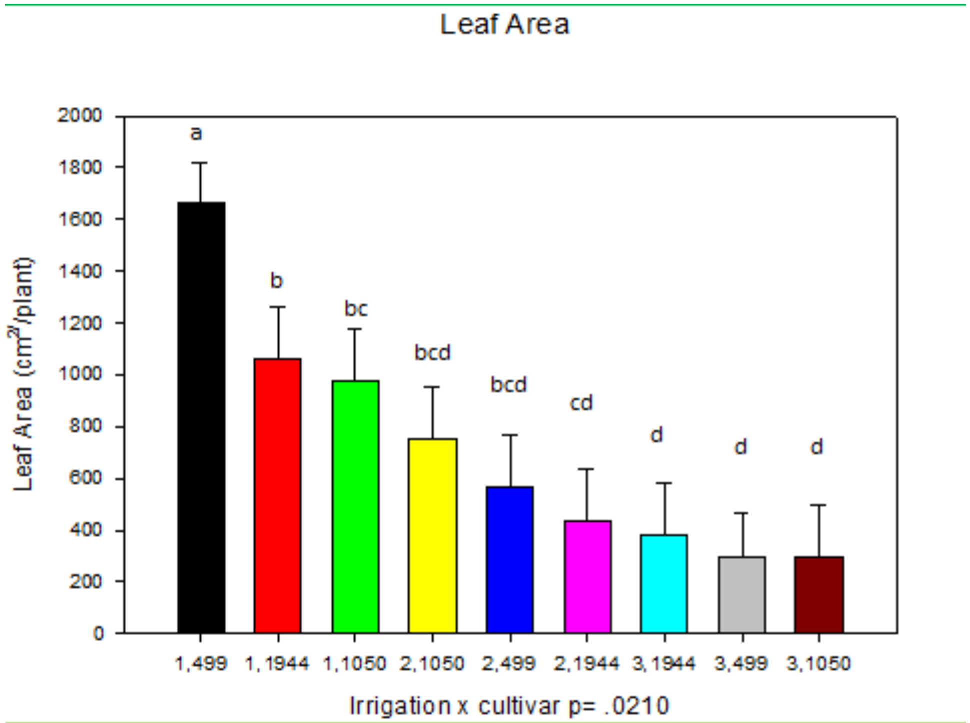

Figure 1. Leaf area collected from cultivars in the Athens greenhouse in 2015 from destructive harvest coinciding with cessation of the experiment. Data and standard errors presented as means averaged over irrigation treatment and cultivar.

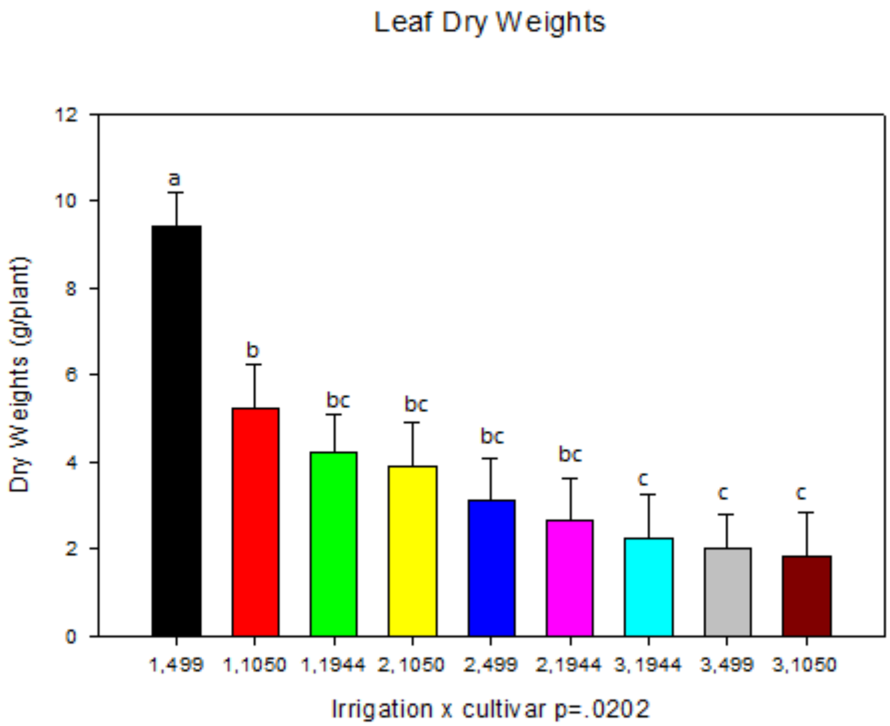

Figure 2. Leaf dry weights collected from cultivars in the Athens greenhouse in 2015 from destructive harvest coinciding with cessation of the experiment. Data and standard errors presented as means averaged over irrigation treatment and cultivar.

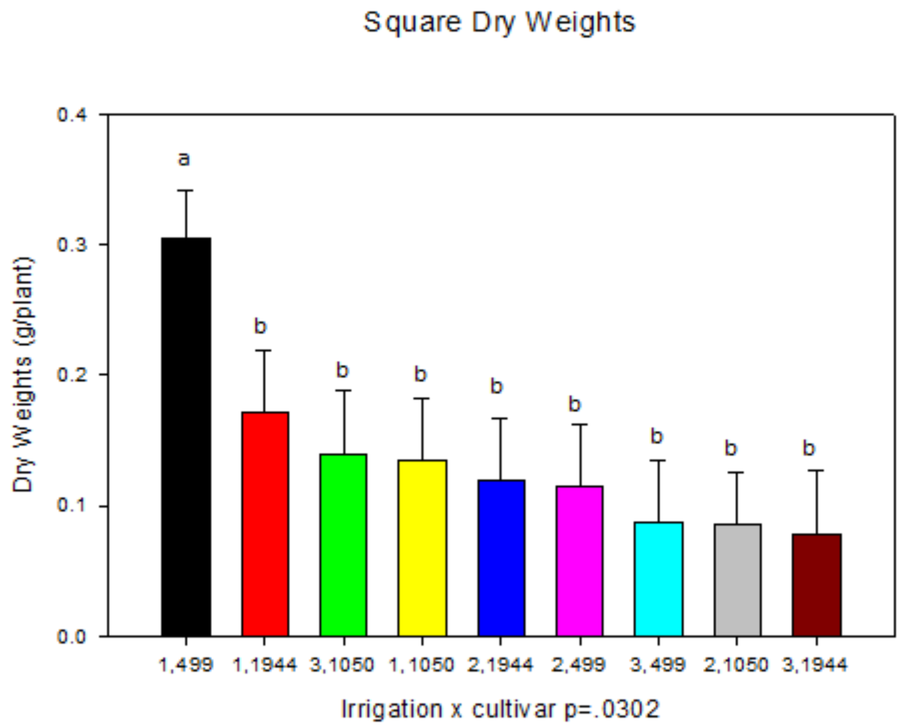

Figure 3. Square dry weights collected from cultivars in the Athens greenhouse in 2015 from destructive harvest coinciding with cessation of the experiment. Data and standard errors presented as means averaged over irrigation treatment and cultivar.

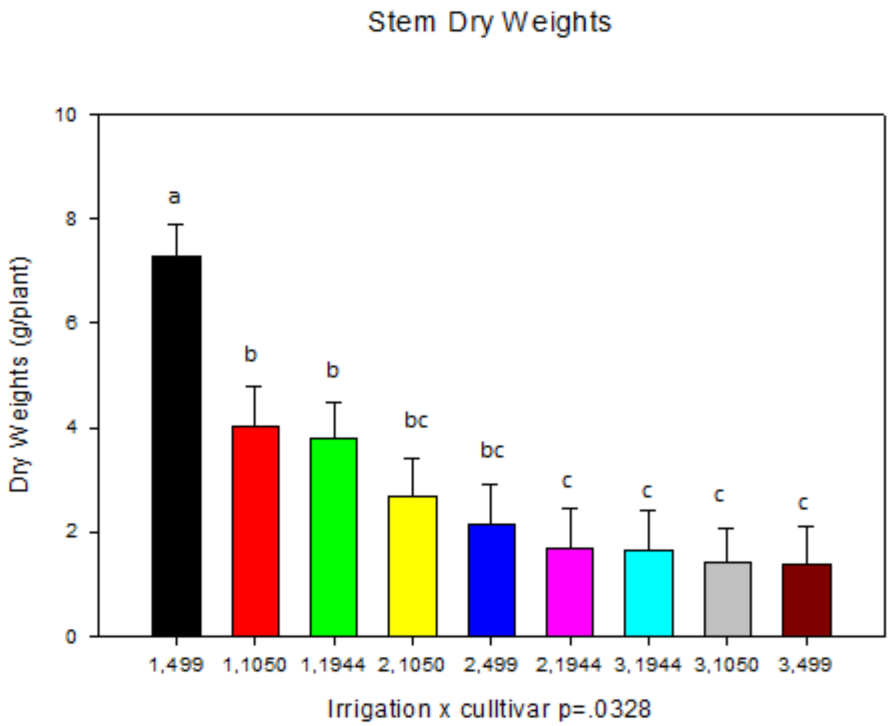

Figure 4. Stem dry weights collected from cultivars in the Athens greenhouse in 2015 from destructive harvest coinciding with cessation of the experiment. Data and standard errors presented as means averaged over irrigation treatment and cultivar.

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References

Pace, P.F., H.T. Crale, S.H.M. El-Halawany, J.T. Cothren, and S.A. Senseman. 1999. Drought induced changes in shoot and root growth of young cotton plants. J. Cotton Sci. 3:183-187.

USING PLANT-BASED IRRIGATION TRIGGERS TO QUANTIFY WATER SAVINGS WITH A RYE COVER CROP

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Introduction

Crop water requirements can vary substantially from one location to another (even within the same field). Because the cotton plant integrates its total environment, any site-specific differences in soil properties, atmospheric conditions, or plant development (rooting depth, leaf area development, etc.) that influence water availability will be manifested in the water status of the plant. Using this logic, a number of authors have proposed using plant-based measurements to detect the onset of water deficit stress and to more accurately schedule irrigation. Recent work in our lab has demonstrated that predawn leaf water potential can be used as an accurate tool for predicting the need for irrigation. Specifically, predawn leaf water potential triggers were used in a 2-year study with five irrigation treatments (The University of Georgia Checkbook approach, three plant-based triggers, and a dryland check) to schedule irrigation in field-grown cotton near Camilla, Georgia. This study demonstrated that plant-based methods could significantly improve water use efficiency (WUE) relative to the checkbook approach without penalizing yield. Furthermore, a water potential of -0.5 MPa (the highest threshold used in that study) was ideal for consistently producing maximum yields, improving WUE and consistently producing the maximum net returns.

Another method touted to improve water savings is the use of a high-biomass cover crop, such as a winter rye cover crop. Although greater soil moisture retention has been noted previously, reports demonstrating improved irrigation efficiency with the subsequent summer crop (e.g. cotton) have been limited, as have studies assessing plant water status and crop growth responses to a rye cover crop. Using plant-based irrigation triggers such as predawn water potential to schedule irrigation should determine the potential for water savings with a rye cover crop because irrigation water would only be applied based on plant demand. Thus the objective of this study was to quantify the water savings associated with the use of a heavy-residue rye cover crop by using predawn leaf water potential irrigation triggers.

Materials and Methods

A field site was established near Tifton, Georgia, in 2015. For rye treatments, rye seed were sown in November 2014 and 20 lb/ac N applied as urea following planting. Prior to planting in May, the cover crop was terminated using roundup and rolled prior to planting. Seeds of *Gossypium hirsutum* cv. FM 1944 GLB2 were sown on May 11, 2015 into strip tilled rows at a 0.91m inter-row spacing and at a rate of 11 seeds m^{-1} row. Plots (n = 4) were eight rows wide, 12.2 m long, and had 2.4 m bare-soil alleys. Fertilization and pest management practices were conducted for each treatment according to University of Georgia Cooperative Extension Service recommendations (Collins et al., 2014).

Prior to imposing irrigation treatments at squaring, a healthy, uniform stand was obtained by supplementing rainfall with overhead sprinkler irrigation. Average plant densities are provided in Figure 6 and were sufficient to produce maximum yields in all treatments. At squaring, irrigation treatments were initiated and consisted of the following: 1) -0.4 MPa predawn water potential threshold, 2) -0.5 MPa predawn water potential threshold, and 3) -0.7 MPa predawn water potential threshold. Plots in these treatments received irrigation water when average predawn leaf water potential (determined using a Scholander pressure chamber) values for a given treatment were equal to or lower than the defined threshold for each treatment, and irrigation decisions were made 2 days per week (Tuesday and Friday). Irrigation and tillage treatments were arranged in a randomized complete block design (n = 6 plots per irrigation treatment). Irrigation was terminated at first open boll for the latest maturing plot.

Predawn (0400 to 0600 hours) leaf water potential measurements (Ψ_{PD} and Ψ_{MD}) were performed according to a modification of the methods of Grimes and Yamada (1982). Ψ_{PD} was measured two days per week for irrigation scheduling purposes (the days on which the irrigation system could be run) except in situations where high rainfall events during predawn hours prevented entry into the field. On each sample date, an uppermost, fully expanded mainstem leaf was excised from the plant. Following leaf excision, the leaf petiole was immediately sealed in a compression gasket with the cut surface of the petiole exposed. The leaf blade was sealed in a pressure chamber (Model 615; PMS Instruments, Albany, OR) and the chamber was pressurized using compressed nitrogen at a rate of 0.1MPa s^{-1} until water first appeared at the cut surface of the stem. The total elapsed time from when the leaf was cut from the plant to the initial pressurization of the chamber was 5 seconds. Values are expressed in MPa.

Crop growth and development was characterized by measuring the plant height and the total number of mainstem nodes per plant for five plants in each plot at 2-week intervals throughout the season. Additionally, the number of mainstem nodes above the first position white flower (NAWF) was determined for 5 plants per plot every week beginning at first flower. At crop maturity, a spindle picker was utilized to harvest two center rows of each plot, and seedcotton weights for each plot were determined using a scale immediately adjacent to the field. These values were used to estimate seedcotton yields. A grab sample was obtained from the seedcotton harvested from each plot and ginned on a table top gin to obtain the gin turnout data needed for lint yield calculations. The effect of irrigation treatment on the aforementioned parameters was assessed using a mixed effects ANOVA where block was a random effect and irrigation treatment was a fixed effect. Post-hoc analysis was conducted using Fisher's LSD (α = 0.05).

Results and Discussion

In plots receiving the rye cover crop treatment, average above ground dry biomass for the cover crop immediately prior to burn down was approximately 350 g/m^2. Roughly two weeks following planting, average stand counts indicated no significant differences in plant population between the rye cover treatment and the conventionally tilled treatment (Figure 1). Neither rye cover crop nor irrigation treatment had a significant impact on lint yield in 2015, likely due to high rainfall. All yields were between three and four bales per acre. Water use efficiency, while not impacted by rye cover crop, was significantly impacted by the different levels of water applied during irrigation treatment. The -0.4 MPa treatment was the least water use efficient, whereas the -0.7 MPa treatment was the most water use efficient and was not significantly different than the -0.5MPa treatment (Figure 2). When considered as season-long averages, predawn water potential was not significantly affected. Irrigation treatment had a significant effect, where the -0.7MPa treatment had the lowest average water potential and the other two treatments produced the highest predawn water potential (Figure 3). Water potential trends throughout the season indicated that the rye cover crop resulted in a higher water potential on one date for treatments irrigated using the -0.5MPa treatment (Figure 4). Because irrigation water could only be applied twice per week, the water potential for each treatment often fell well below the intended thresholds (Figure 4). NAWF was significantly affected by rye cover crop for the -0.5 MPa treatment only on the last sample date, indicating a slower rate of NAWF decline (cutout) for the rye, -0.5MPa treatment (Figure 5) when compared with all other treatments. Neither irrigation treatment nor tillage had a significant impact on seasonal plant height or node development trends (Figure 6).

Although leaf water potential-based irrigation thresholds ranging from -0.4 to -0.7 MPa did not significantly impact yield in 2015, because different amounts of irrigation water were applied, the -0.7 MPa threshold had the lowest season average water potential, was the most water use efficient, and was comparable in WUE to the -0.5 MPa treatment, which has been previously shown to produce maximum water use efficiency in cotton. While the rye cover crop did illustrate some potential to maintain higher water potential than conventionally tilled plots briefly during the season, this response was not sufficient to result in higher WUE for cotton grown following a high biomass rye cover crop.

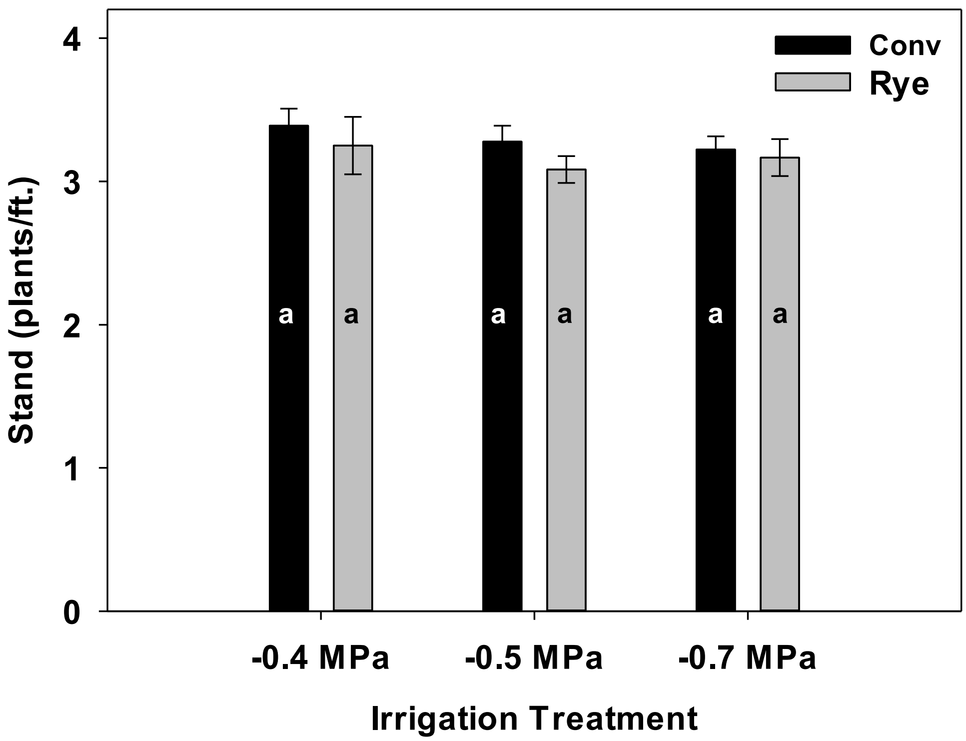

Figure 1. Average number of plants per row ft two weeks after planting (planting date = May 11, 2015) for cotton planted into conventionally tilled plots or a rye cover crop and for three irrigation treatments at a field site near Tifton, GA. Data are means ± SE (n = 6).

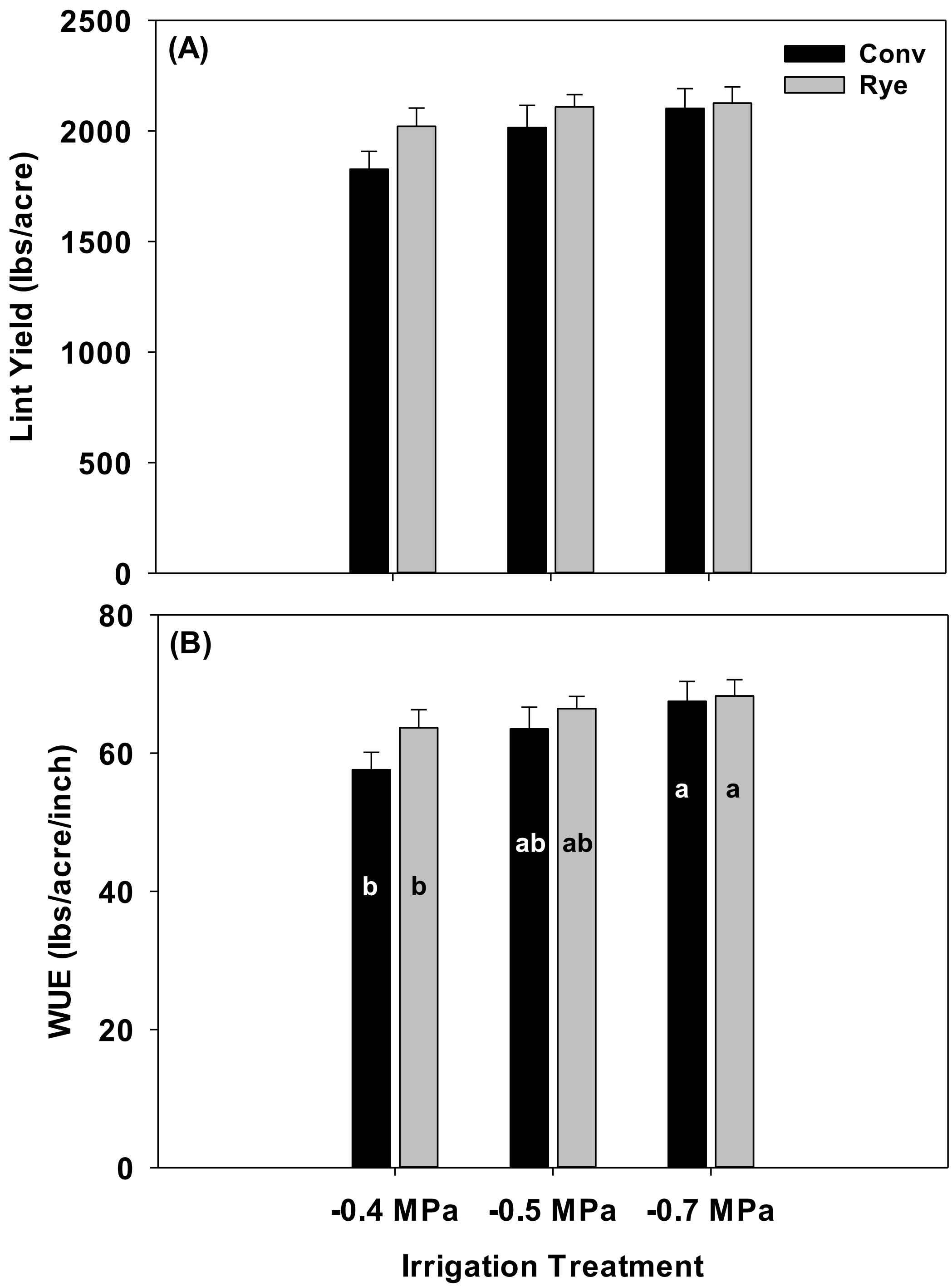

Figure 2. Average lint yield and water use efficiency for cotton planted into conventionally tilled plots or a rye cover crop and irrigated according to three predawn leaf water potential thresholds (-0.4, -0.5, and -0.7 MPa) at a field site near Tifton, GA. Data are means ± SE (n = 6).

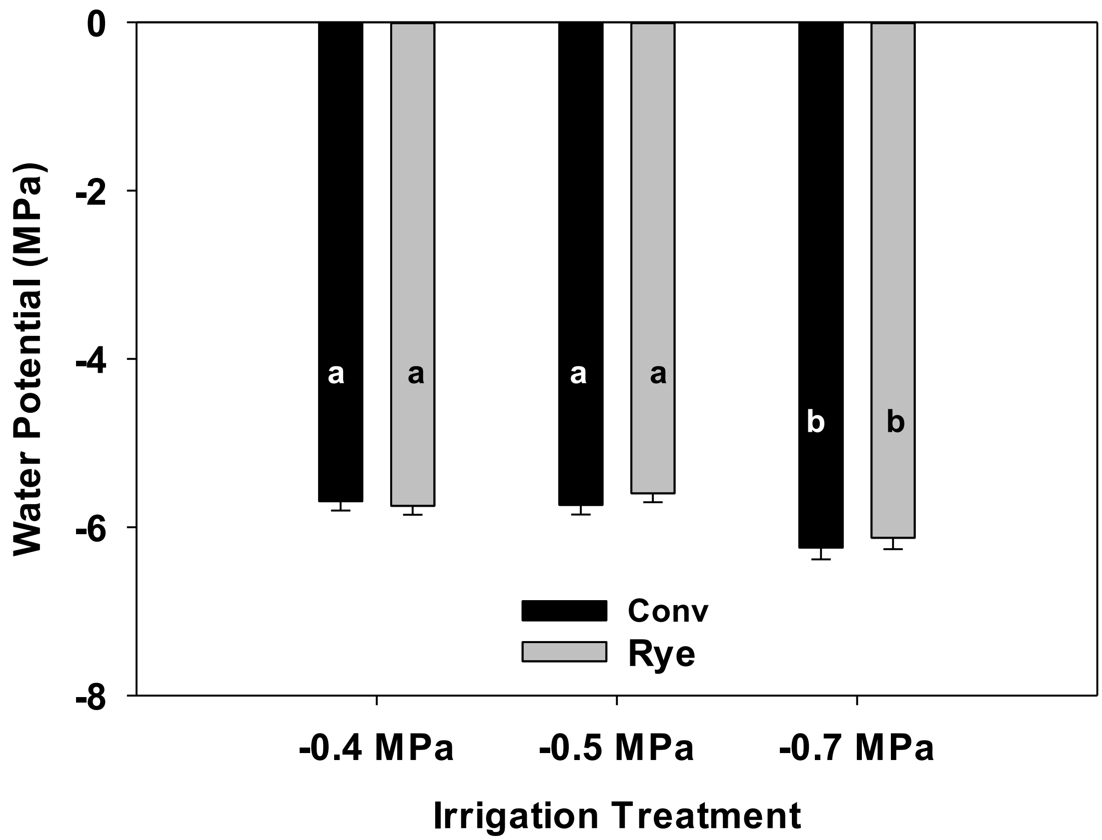

Figure 3. Season-long average predawn leaf water potential for cotton planted into conventionally tilled plots or a rye cover crop and irrigated according to three predawn leaf water potential thresholds (-0.4, -0.5, and -0.7 MPa) at a field site near Tifton, GA. Data are means ± SE (n = 6).

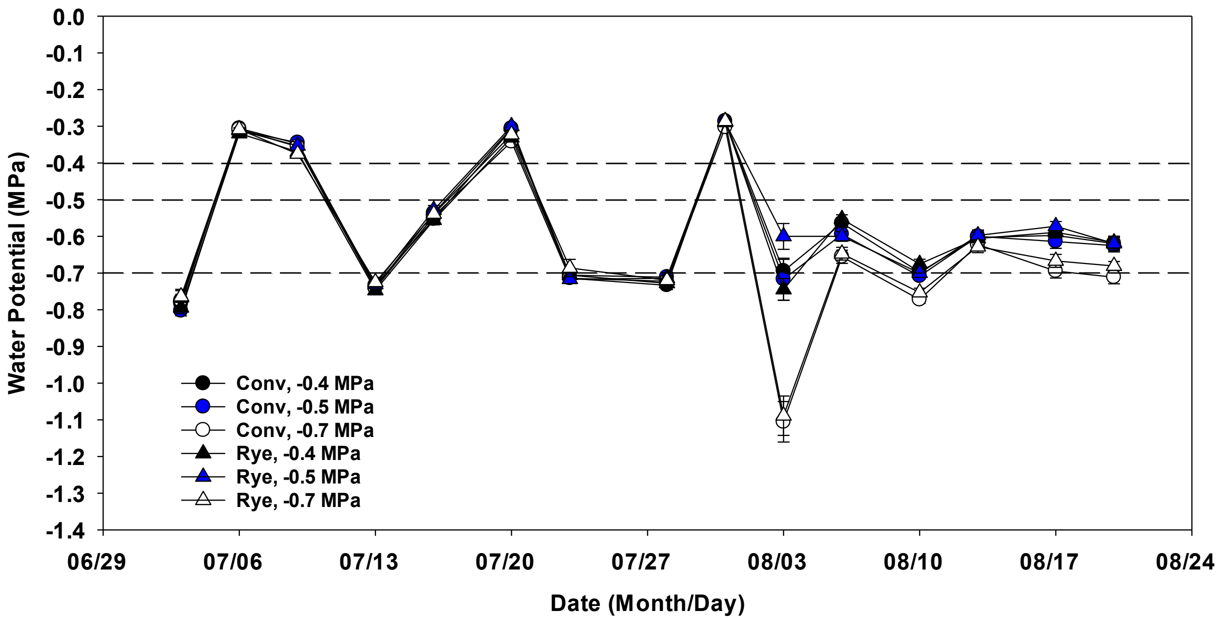

Figure 4. Predawn leaf water potential throughout the 2015 growing season for cotton planted into conventionally tilled plots or a rye cover crop and irrigated according to three predawn leaf water potential thresholds (-0.4, -0.5, and -0.7 MPa) at a field site near Tifton, GA. Data are means ± SE (n = 6).

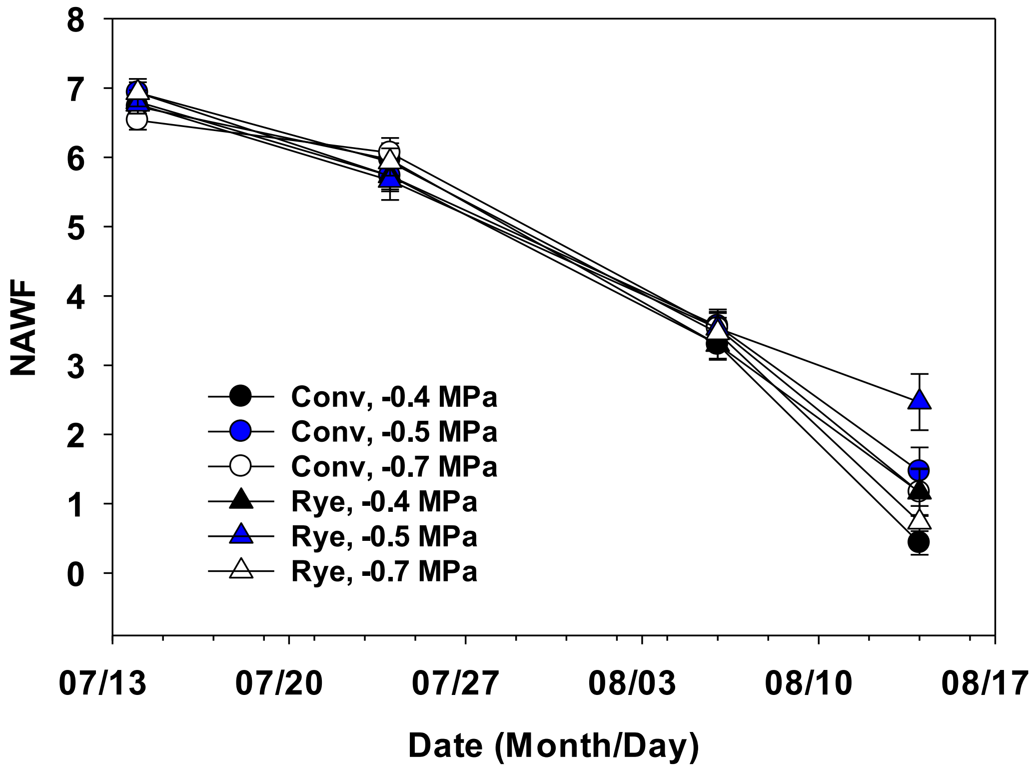

Figure 5. Number of mainstem nodes above the uppermost first position white flower on four different sample dates throughout the 2015 growing season for cotton planted into conventionally tilled plots or a rye cover crop and irrigated according to three predawn leaf water potential thresholds (-0.4, -0.5, and -0.7 MPa) at a field site near Tifton, GA. Data are means ± SE (n = 6).

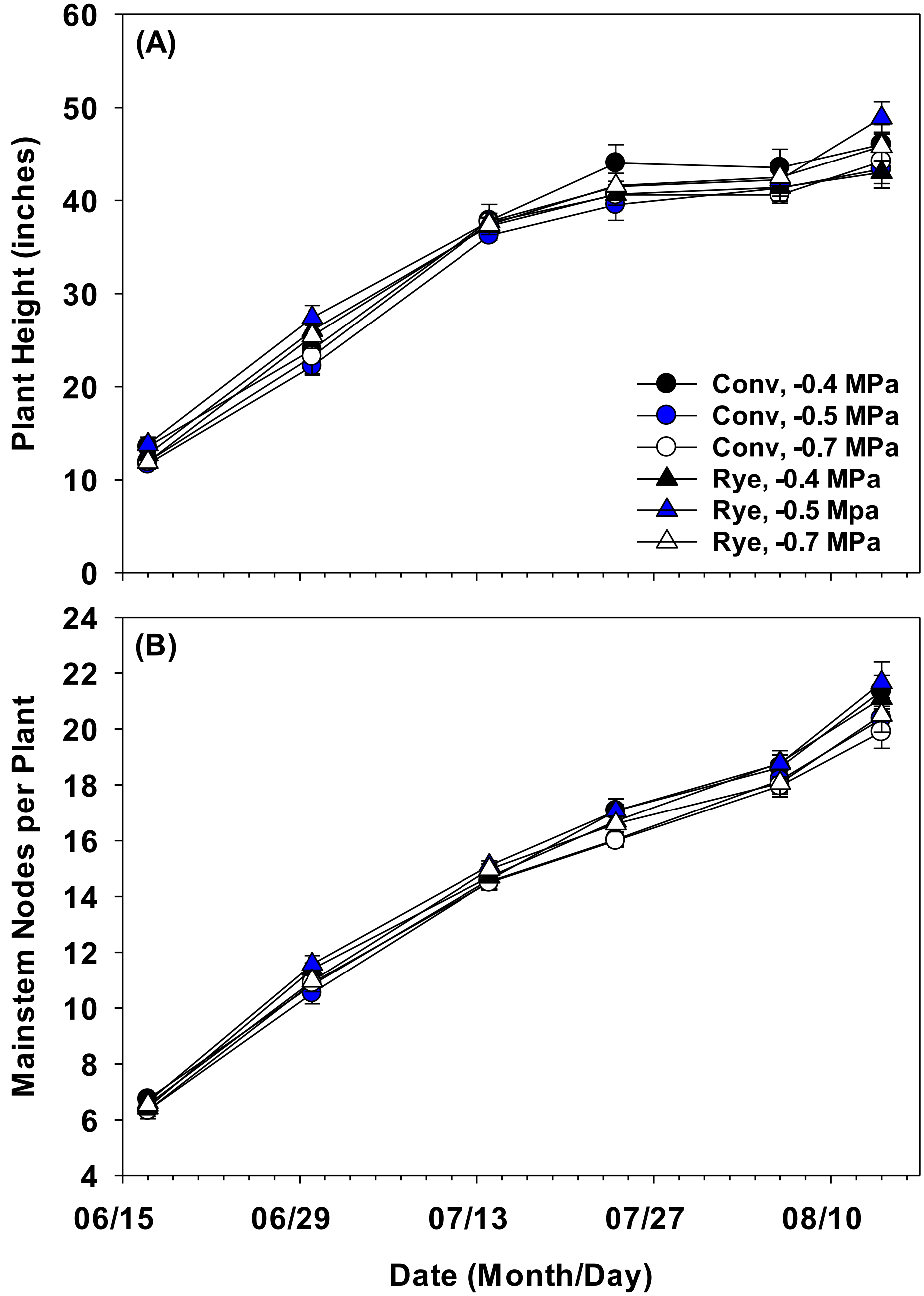

Figure 6. Average plant height (A) and number of mainstem nodes (B) on six different sample dates throughout the 2015 growing season for cotton planted into conventionally tilled plots or a rye cover crop and irrigated according to three predawn leaf water potential thresholds (-0.4, -0.5, and -0.7 MPa) at a field site near Tifton, GA. Data are means ± SE (n = 6).

Acknowledgements

The authors would like to thank the Georgia Cotton Commission, Cotton Incorporated, and the University of Georgia for support of this project.

References

Grimes, D. and H. Yamada. 1982. Relation of cotton growth and yield to minimum leaf water potential. Crop Sci. 22:134-39.

Collins, G.D., J. Whitaker, S. Culpepper, G. Harris, B. Kemerait, C. Perry, P. Roberts, D. Shurley, and A. Smith. 2014. 2014 Georgia cotton production guide. Publication No. CSS-14-01. University of Georgia Cooperative Extension Service, Tifton, GA.

ASSESSING THE UTILITY OF PHYSIOLOGICAL METHODS TO IDENTIFY DROUGHT SENSITIVITY IN COMMERCIAL COTTON CULTIVARS

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Introduction

A number of rapid, non-destructive techniques using chlorophyll fluorescence and other physiological parameters have been proposed to screen for drought stress tolerance. The appeal of chlorophyll fluorescence is that it is rapid (1 second per measurement) and a large number of parameters can be determined per reading (quantum yield, electron transport rate, etc.). Net photosynthesis is widely recognized as an important indicator of plant performance under a range of conditions (including water deficit), and recent work indicates that predawn respiration measurements may be highly predictive of yield-limiting drought stress (Snider et al. 2015). However, information is somewhat limited on the efficacy of using chlorophyll fluorescence and other physiological parameters to detect cultivar specific differences in yield performance under dryland conditions. This information will be exceptionally useful in identifying a meaningful and rapid screening tool for drought tolerance in commercially available cotton. Thus the objective of the current study was to identify sensitive and timely physiological indicators of drought stress in cotton exposed to dryland conditions imposed during the first few weeks of flowering.

Methods

The experimental design was completely randomized, with four replicate plots for each of three varieties (PHY 499, FM 1944, DP 1050) under rainout shelters at the UGA Tifton campus. Each plot consisted of two rows approximately 2 meters in length drip irrigated to UGA checkbook recommendations until first flower. At that time, irrigation ceased and the rainout shelter was employed to ensure that no precipitation was received for three weeks. During this time, chlorophyll fluorescence-based measurements were performed weekly along with infrared gas exchange measurements and predawn water potential measurements. After the 3-week stress, irrigation resumed. Yield was determined at the end of the season following hand harvest of each plot. Water potential measurements were obtained using a pressure chamber. Gas exchange and fluorescence measurements are described below.

In-field gas exchange and fluorescence measurements for leaves at Node 4 below the terminal were conducted using a Portable Photosynthesis System (Model LI-6400, LI-COR, Lincoln NE) with a Leaf Chamber Fluorometer (Model LI-6400-40, LI-COR, Lincoln, NE). Pre-dawn leaf respiration rates (R_n) were also estimated using an LI-6400 portable photosynthesis system (Li-Cor, Lincoln, NE), where all leaves were measured before sunrise between 0400 and 0600 h and at chamber CO_2 = 400 p.p.m. flow = 300 μmol s^{-1}. Steady-state respiration rates were obtained approximately 120 s after the leaf was enclosed in the leaf chamber.

For midday (1200 to 1400 h) net photosynthesis (P_N) and light-adjusted chlorophyll fluorescence measurements, flow rate was set to 500 μmol s^{-1}, block temperature was set to ambient air temperature, chamber CO_2 concentration was set at 400 ppm, and photosynthetic photon flux density (*PPFD*) = 2000 μmol m^{-2} s^{-1}, which is considered an above-saturating light intensity for cotton (Constable & Rawson 1980; Ehleringer & Hammond 1987). Once steady state P_N was achieved, the data were logged (roughly 60 s after the leaf was enclosed in the chamber). At the same time as photosynthesis measurements were conducted, photosynthetic electron transport rate (ETR) was estimated using chlorophyll fluorescence.

Results and Discussion

The primary findings of the current study are that rain exclusion resulted in low and variable yields for cotton when the crop was exposed to drought stress for three weeks beginning at the onset of flowering (Figure 1). However, the cultivars used in the current study did not differ in yield, respiration rates, water potential, net photosynthesis or photosynthetic electron transport rates (Figures 1 and 2), indicating that no significant differences in drought tolerance existed between the varieties used in the current study. Regarding the potential of various physiological methods to detect cultivar differences in drought tolerance, it is important to note that none of the cultivars used in the current study differed in yield or physiological response to drought. Thus, future work should target genotypes that differ more widely in tolerance to water deficit if suitable drought tolerance screening tools are to be assessed.

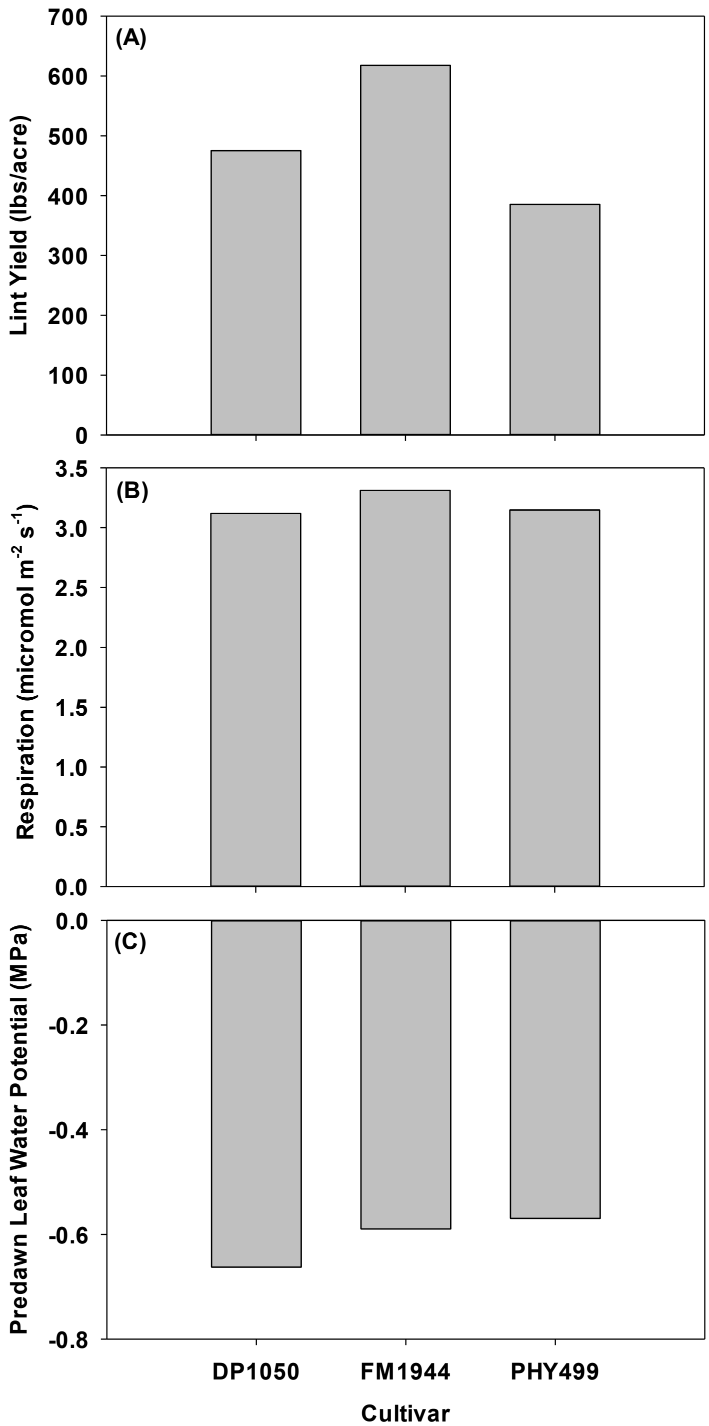

Figure 1. Average lint yield for three cotton cultivars (DP1050, FM1944, and PHY499) exposed to a three week water exclusion period beginning during the first week of flowering (A) and the average predawn respiration (B) and the average predawn leaf water potential (C) for the entire three week rain exclusion period for cotton grown at a site in Tifton, GA during the 2015 growing season. Data are means ± SE (n = 4).

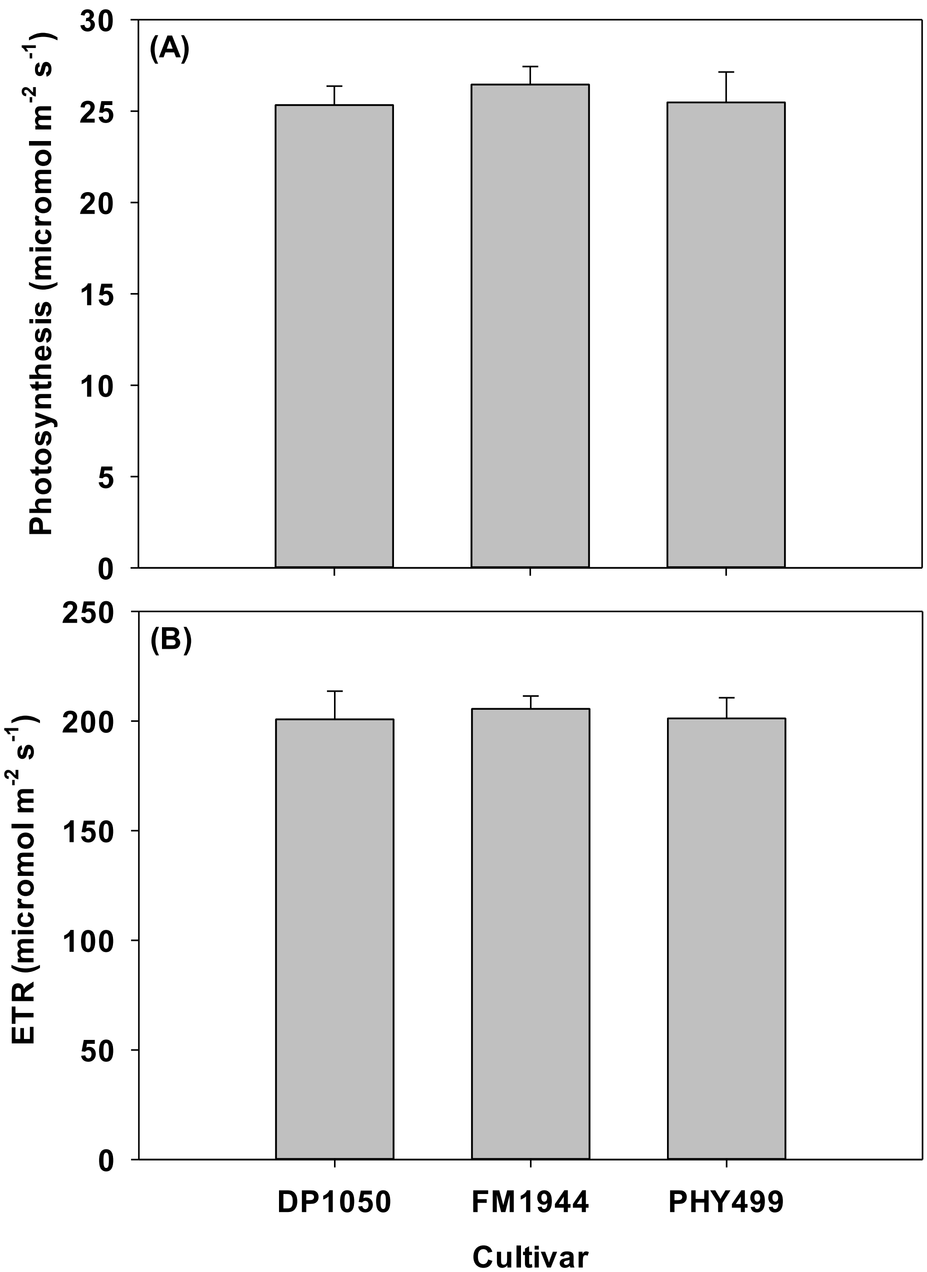

Figure 2. Average net photosynthetic rate (A), and photosynthetic electron transport rate (B) for three cotton cultivars (DP1050, FM1944, and PHY499) exposed to a three week water exclusion period beginning during the first week of flowering (A) and the average predawn respiration (B) and the average predawn leaf water potential (C) for the entire three week rain exclusion period for cotton grown at a site in Tifton, GA during the 2015 growing season. Data are means ± SE (n = 4).

Acknowledgements

The authors would like to thank the Georgia Cotton Commission, Cotton Incorporated, and the University of Georgia for support of this project.

References

Constable, G. and H. Rawson. 1980. Effect of leaf position, expansion and age on photosynthesis, transpiration and water use efficiency of cotton. *Aust. J. Plant Physiol.* 7: 887-894.

Ehleringer, J. and S. Hammond. 1987. Solar tracking and photosynthesis in cotton leaves. *Agricult. Forest Meteorol.* 39: 25-35.

Snider, J.L., D.R. Chastain, C.D. Meeks, G.D. Collins, R.B. Sorensen, S.A. Byrd, and C.D. Perry. 2015. Predawn respiration rates during flowering are highly predictive of yield response in *Gossypium hirsutum* when yield variability is water-induced. *J. Plant Physiol.* 183:114-120.

THE EFFECTS OF SOIL MOISTURE ON COTTON GROWTH AND YIELD: A MULTI-VARIETAL INVESTIGATION

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Abstract

The main objective of this project was to quantify the effect of total water received and the corresponding soil moisture levels on final crop yield in a variety of production scenarios common to Georgia. The secondary objectives of this study were to determine the effect of total water received throughout the growing season on the development of the crop, the progression toward crop maturity, and to determine the effect of total water received during critical growth stages on final seed cotton yield. Rainfall, irrigation, soil moisture, and maturity data were collected throughout the cotton production season approximately every two weeks in twenty cotton variety trials in the southern region of Georgia. Soil moisture data were collected using AquaCheck capacitance probes (AquaCheck Brackenfel, Cape Town, South Africa); rainfall and irrigation data were collected using Rain-O-Matic Small tipping bucket rain gauges (Fjord Alle 8, DK-6950 Ringkobing) equipped with Decagon EM-50-R data loggers (Decagon Devices Hopkins Ct, Pullman, WA). There were a variety of soil types, and tillage and irrigation methods utilized in the trials, which have all been noted. Little correlation was found between the amount of water the crop received pre-bloom and yield. However, stronger correlations were found between the total water received during the season and final seed cotton yield. Trials that received more rainfall or irrigation during flowering typically had higher yields than treatments receiving lower amounts of water during this growth stage. Overall, well-timed irrigation during critical growth stages produced higher yields, which provides evidence showing that on cotton it is most critical to provide the University of Georgia recommended amount of water during squaring through bloom (UGA Cotton Production Guide).

Introduction

In 2014, Georgia produced over 2.5 million bales of cotton from 1.3 million harvested acres, ranking it second in national cotton production. Georgia's cotton production is very important to the state's agricultural industry, valued at $770 million (USDA/NASS). The high value of this industry to the state has created a critical need for access to water. Limited access to water has become an issue nationwide and has forced producers to make an effort to reduce water use. Improving water use efficiency is a necessity in many areas and is likely to become more of a concern in the future; however, incurring a reduction in yield is undesirable, especially with current commodity prices making water management critical. Significantly reducing the water availability may have undesirable effects and could cause yield loss. For instance, reducing the amount of water applied can reduce shoot growth resulting in a lower number of fruiting sites on the plant. More available water increases growth, delays cutout, and increases fruiting sites available to support a large boll load (Gwathmey et. al 2011). Increasing irrigation efficiency has the potential to save growers valuable time and capital that can be devoted to other areas of their operation. Hiler & Howell reported that careful distribution of water over the course of the season could be the solution to using water more wisely through careful conservation (1983).

A proper, strictly followed irrigation scheduling plan implemented during the growing season could reduce the amount of water used and ensure that it is applied at critical times. Finding the most crucial times during the season to apply irrigation would save producers valuable time, resources, and money while positively impacting yield. Ideal irrigation management in Georgia has been shown to increase yields by up to 312 lb/ac (Simao et. al 2013). Yield has the potential to be increased by implementing improved irrigation strategies that are catered to individual spatial and temporal conditions. Many researchers disagree about which growth stage is most critical to applying irrigation. Yield loss can be incurred due to drought stress at any growth stage, but determining the most crucial stages to apply irrigation could aid in maintaining the yield potential of that crop. Innumerable environmental pressures and genetically predetermined factors influence yield, but careful irrigation management could negate some of these factors to improve yield potential.

Not only yield, but crop growth parameters such as the total number of nodes and the height of plants was shown to have been impacted when the crop experienced drought stress during the period of squaring to flowering, resulting in a reduced yield (Snowden et. al 2014). Fiber quality can be impacted by drought stress during certain stages of growth, specifically after peak bloom (Snowden et. al 2014). Some have concluded that one of the most critical times to avoid drought stress and avoid yield loss is during flowering and peak bloom (Sheedy et. al 1997). This yield loss is believed to be due to significant square shedding and eventually boll loss following the drought stress (Snowden et. al 2014). Yield has been shown to be negatively affected during early flowering (Simao et. al 2013). A water deficit during early flowering can cause yield loss of up to 60%, relative to a well-watered crop. Drought stress from squaring to flowering, at peak bloom, and from peak bloom to termination can cause up to a 35% yield loss at each of these growth stages (Snowden et. al 2014). Determining the ideal irrigation schedule for cotton in a variety of environments could be instrumental in increasing efficiency in production and water conservation.

Objectives

The main objective of this project was to quantify the effect of total water received and the corresponding soil moisture levels on final crop yield in a variety of production scenarios common to Georgia. The secondary objectives of this study were to determine the effect of total water received throughout the growing season on the development of the crop, the progression toward crop maturity, and to determine the effect of total water received during critical growth stages on final seed cotton yield.

Materials and Methods

A combination of thirteen on-farm cotton variety trials (OFT) and seven UGA Official Variety Trials (UGA OVT) were selected for a total of twenty site locations. The sites were located across the eastern and western parts of South Georgia. Locations of the OFT trials included Burke, Screven, Washington, Appling, Tatnall, Evans, Montgomery, Bleckley, Early, Grady, and Mitchell counties. Tift, Decatur, Sumter, and Burke counties were the locations of the UGA OVT trials. There were nine irrigated and eleven dryland trial locations. Within 1 to 2 weeks after emergence, soil moisture sensors and rain gauges were installed. There was not a specific irrigation schedule given for the growers to follow. Each of the growers maintained the irrigation for these trials as needed. Only the distribution and total amount of irrigation were compared with the water received by the dryland trials.

To collect rainfall and irrigation data two small Rain-O-Matic tipping bucket rain gauges (Fjord Alle 8, DK-6950 Ringkobing) were fixed onto a board and placed in each of the plots (Figure 1). Two tipping bucket rain gauges were used to ensure that the data from at least one could be recorded in case of equipment failure. The data from the tipping bucket rain gauges were collected using a Decagon EM-50-R data logger (Decagon Devices Hopkins Ct, Pullman, WA). Rainfall and irrigation were recorded in inches at hourly intervals and downloaded as an Excel data sheet from the data logger.

AquaCheck capacitance probes (AquaCheck Brackenfell, Cape Town, South Africa) were utilized to collect soil moisture data at the twenty cotton variety testing locations (Figure 2). These soil moisture sensors were equipped with on-board memory and were powered with a battery. The depths at which soil moisture was measured with the AquaCheck probes were 8, 16, and 24 inches. Soil moisture data were recorded in percent volumetric water content (VWC) in hourly intervals. Soil moisture data were downloaded wirelessly every two weeks with an AquaCheck RF logger. After data were collected, the AquaCheck Logger Upload Utility was used to upload the file to agri-data.net (Figure 3). Once the file was uploaded, data from each probe were displayed in a graph specific to each probe and site location.

To evaluate the effects of different irrigation treatments, crop development was monitored by selecting fifteen plants from the area around the data loggers every two weeks. These plant measurements corresponded with the same times the rain gauge and soil moisture sensor data was downloaded from the in-field data loggers. Number of true leaves, total nodes, days after squaring and nodes above white flower were all recorded for each of the fifteen plants that were an average representation of the area.

Results and Discussion

There was little correlation observed between the amount of rainfall and irrigation received pre-bloom and the final yield of the crop (Figure 4). The amount of rainfall and irrigation received pre-bloom included the amount of rainfall and irrigation recorded by the rain gauges from the time they were installed (1 to 2 weeks after emergence) until the first bloom was observed in each trial. The poor correlation between the amount of water received pre-bloom and yield could potentially be due to the crop's very low water requirement prior to squaring. Rapid root growth takes place prior to squaring and excessive moisture during this growth stage could impede the growth of the roots, subsequently limiting the further growth of the plant. During squaring, water deficit is not likely to be a problem. Excessive amounts of water during squaring could cause square shedding and decrease yield (Perry 2012 et al.).

The full season total amount of water received plotted versus the final yield is represented in Figure 5. Stronger correlations were found between the amount of rainfall and irrigation received throughout the season and yield. Typically with an increase in rainfall or irrigation there was an increase in yield. There were two exceptions to this case, Grady and Bleckley dryland. Grady dryland yielded 1626 lb/ac and received about 13 inches of rainfall over the season. The monthly distribution of rainfall for the Grady dryland trial is shown in Figure 7. As represented in this figure, Grady received very well timed irrigation, especially during month three, which was during squaring to flowering. Similar results can be viewed in Figure 9 for the Bleckley trial.

Bleckley did not receive as much rainfall during month three as did Grady, but the rainfall was well timed, allowing the crop to produce sufficient yield at the end of the season.

As represented in Figure 6, there was a nearly 1000 lb/ac yield increase in Midville Irrigated compared to the adjacent dryland trial. Midville Irrigated had a yield of 1702 lb/ac while the Midville Dryland trial only had a yield of 737 lb/ac. This is a considerable yield increase, possibly contributed by the increased amount of irrigation received during squaring and flowering. Trials shown in Figure 6 received about the same amount of rainfall in the first month. Amounts of rainfall or irrigation received during the first, fourth, and fifth months are very similar. However, during the second and third months (which would have been during squaring and flowering) the irrigated trial received much more water, or irrigation in this case, which likely contributed to its significantly higher yield.

The monthly breakdown of rainfall received in the Grady and Mitchell dryland trials is represented in Figure 7. Grady Dryland's final yield was 1626 lb/ac and Mitchell Dryland's yield was 607 lb/ac. Each trial received comparable amounts of rainfall during the first month. Mitchell Dryland received about an inch more in the second month than Grady Dryland. However, during the third month, which would have been during flowering, Grady Dryland received 3 inches of rainfall more than Mitchell Dryland. This difference in rainfall received during the critical growth period more than likely contributed to Grady Dryland's 1000 lb/ac increase in yield. The total water requirement for cotton during bloom ranges from 1.5 to 2 inches per week, therefore, during the third month the crop needed between 6 to 8 inches of water. As can be seen in Figure 7, Mitchell fell far short of this, and Grady received between three-quarters to half of the required amount, however, the additional rainfall received by Grady added to the additional yield above that of the Mitchell trial.

The total rainfall received by Grady and Midville trials is shown in Figure 8. Grady Dryland yielded 1626 lb/ac and Midville Irrigated yielded 1702 lb/ac. Midville irrigated received about 9 inches more rainfall and irrigation than Grady dryland. This increase in rainfall and irrigation only increased yield by 76 lb/ac. In this case irrigation/rainfall did not appear to be the yield limiting factor. The addition of the extra irrigation to the Midville trial only increased production costs since there was no yield benefit.

The total amount of rainfall received by Appling and Bleckley dryland from the time sensors were installed until cutout shows similar yields with different amounts of rainfall received (Figure 9). Each trial had similar yields where Appling dryland yielded 1132 lb/ac and Bleckley dryland yielded 1085 lb/ac. Appling dryland received about 7 inches more rainfall and irrigation than Bleckley dryland. This increase in rainfall only increased yield by 47 lb/ac. In this case, the additional rainfall—especially very early and very late in the season—had no additional yield benefit. This trial shows that it is more critical to receive the additional rainfall/irrigation during flowering to have an impact on yield, and that poorly distributed water applied to the crop is not beneficial.

The similar amount of rainfall/irrigation received by Screven irrigated and Burke irrigated from the time sensors were installed until cutout shows that the amount of water received is not the most important element. Instead, the distribution of this water aids in producing the highest yield levels (Figure 10). Screven irrigated yielded 1079 lb/ac and Burke irrigated yielded 1510 lb/ac. Screven irrigated received more rainfall and irrigation, but there was only a .5 inch difference in rainfall and irrigation amounts over the season. The difference in overall irrigation did not matter as much as when the water was applied. A more equal distribution over the season likely contributed to an increase in yield in Burke irrigated. The excessive rainfall during the squaring to flowering stages in this case more than likely added to the reduction in yield in the Screven trial. As stated by Perry et al., excessive amounts of water during squaring could cause square shedding and decrease yield. Since the amount of irrigation/rainfall received during this stage on the Screven trial was much higher than required, it is very probable that square shedding occurred. The Burke trial had an amount of rainfall/irrigation that was closer to the crop requirement applied, thus helping it to produce a higher yield in this case.

Conclusions

Twenty trials were monitored for rainfall, irrigation, and soil moisture across the southern part of Georgia in order to help quantify the effect of water received at different growth stages on final crop yield. Overall, strong correlations were not found due to a high number of sites and inability to monitor fields continually. Very weak correlations were found between pre-bloom total water received and final yield, suggesting that there is little correlation to how the crop will perform based on the amount of rainfall and irrigation it receives pre-bloom. The same poor correlations were found between the volumetric water content pre-bloom and final yield. Stronger correlations were found between total water received over the entire season and final yield. Primed acclimation studies have shown that cotton has the ability to recover from water stress early in the season (pre-squaring and bloom) if ample water is received once the crop reaches bloom. This strengthens the argument that timing of irrigation throughout the season, especially during bloom, is very critical. Rainfall and irrigation distribution was shown to be the most important factor on final crop yield throughout the season. Different trials showed that excessive water pre-bloom did not help to compensate for a lack of rainfall during bloom, while other trials supported the argument that a lack of sufficient water pre-bloom could be compensated for by the addition of sufficient well distributed water during the bloom period. Growing degree days seemed to have a small influence that affected some of the trials final yield, but not as significantly as water distribution. Excessive amounts of water received by the crop in some cases appeared to have limited the crop yield. There were also trials in which no additional yield benefit was found when the total amount of applied irrigation or rainfall exceeded the amount required by the crop for that particular growth stage. The critical point that can be gathered from this research is that the timing and amount of irrigation and/or rainfall during critical growth stages of the crop, specifically during bloom on cotton, has the largest impact on final crop yield.

Figure 1. Decagon EM-50-R data logger and the tipping bucket rain gauges.

Figure 2. AquaCheck capacitance probe used for monitoring volumetric water content at each of the trial locations.

Figure 3. An example of a graph of the soil moisture data from agri-data.net.

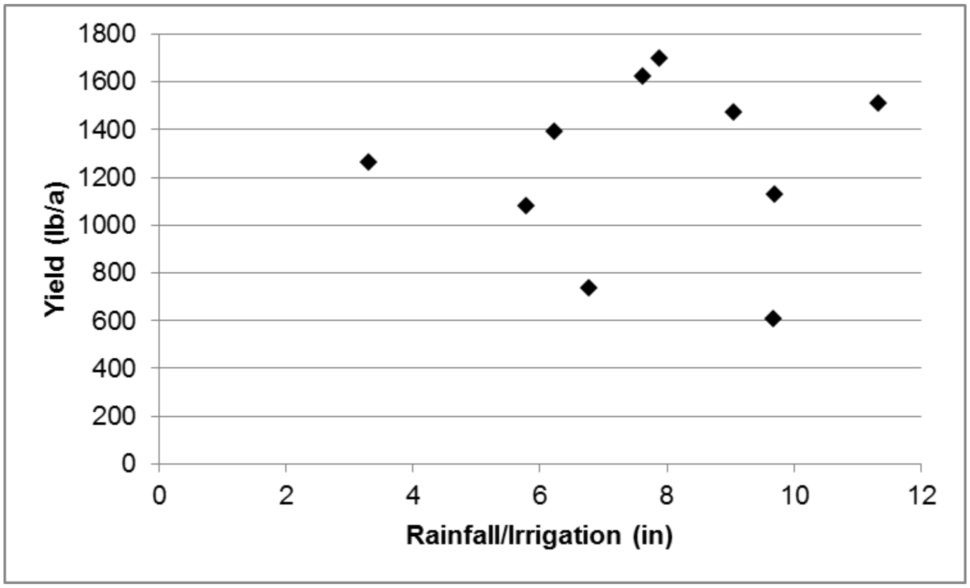

Figure 4. Correlations between rainfall and irrigation received pre-bloom and yield.

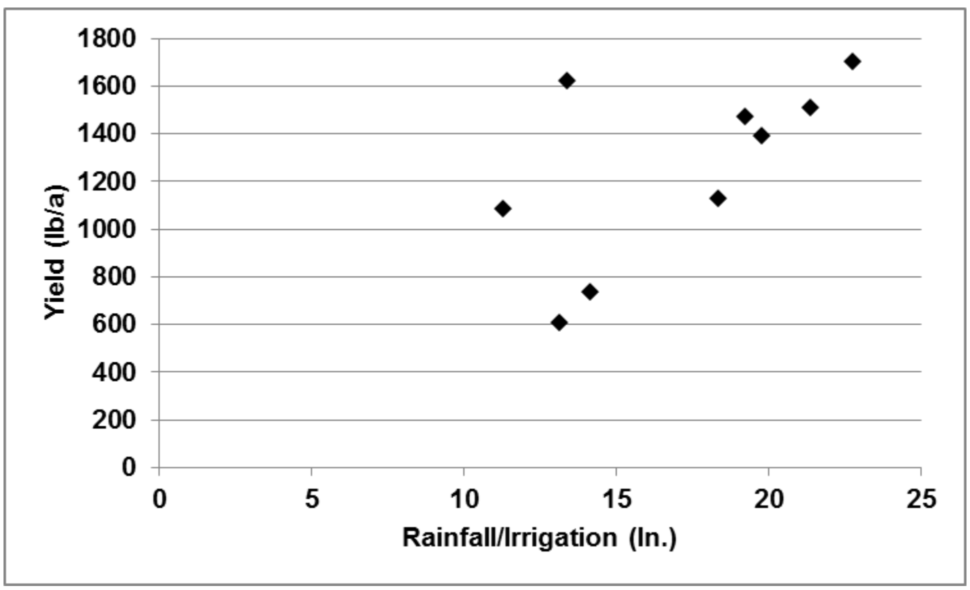

Figure 5. Correlations between rainfall and irrigation received throughout the season and yield.

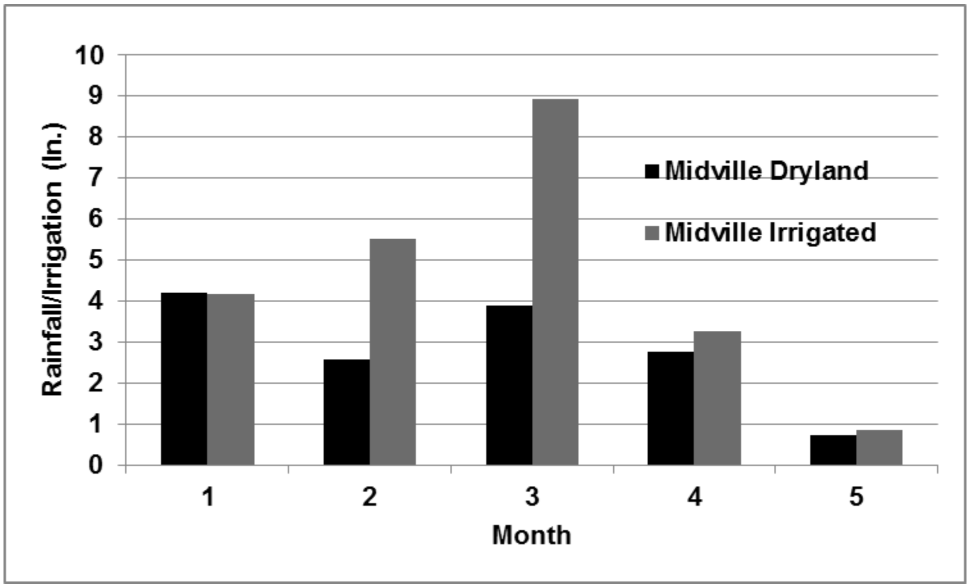

Figure 6. The amount of rainfall/irrigation recorded by rain gauges in both Midville Dryland (black) and Midville Irrigated (grey) from the time that sensors were installed until cutout. The lower amount of rainfall recorded during month 5 is due the sensors being uninstalled during that time.

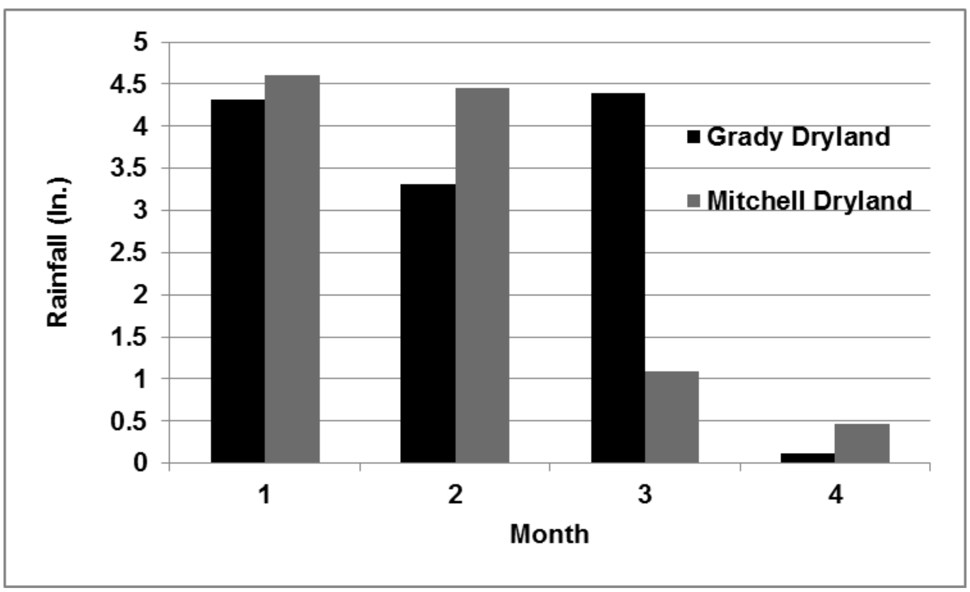

Figure 7. The amount of rainfall/irrigation recorded by rain gauges in both Grady Dryland (black) and Mitchell Dryland (grey) from the time that sensors were installed until cutout. The lower amount of rainfall recorded during month 4 is due the sensors being uninstalled during that time.

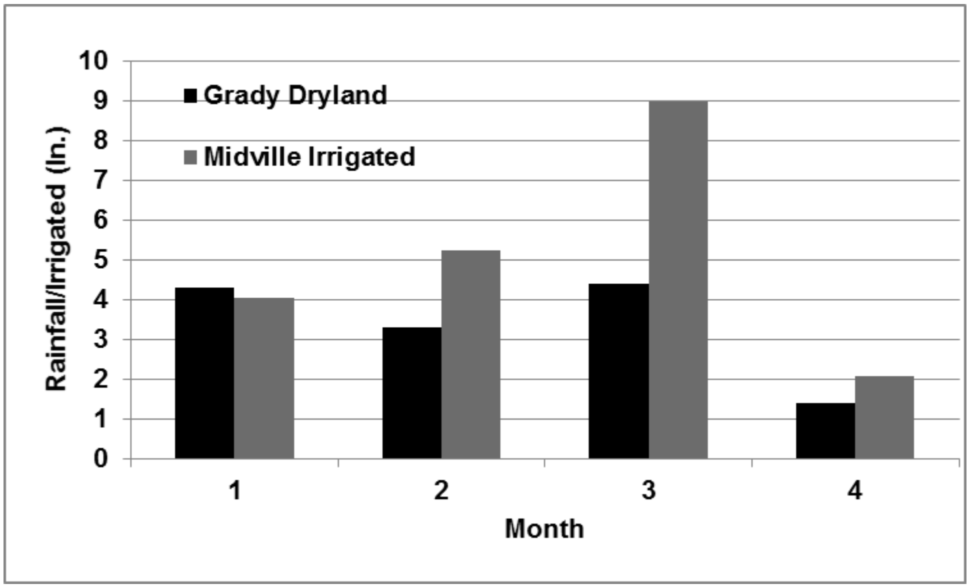

Figure 8. The amount of rainfall/irrigation recorded by rain gauges in both Grady Dryland (black) and Midville Irrigated (grey) from the time that sensors were installed until cutout. The lower amount of rainfall recorded during month 4 is due the sensors being uninstalled in Grady Dryland during that time.

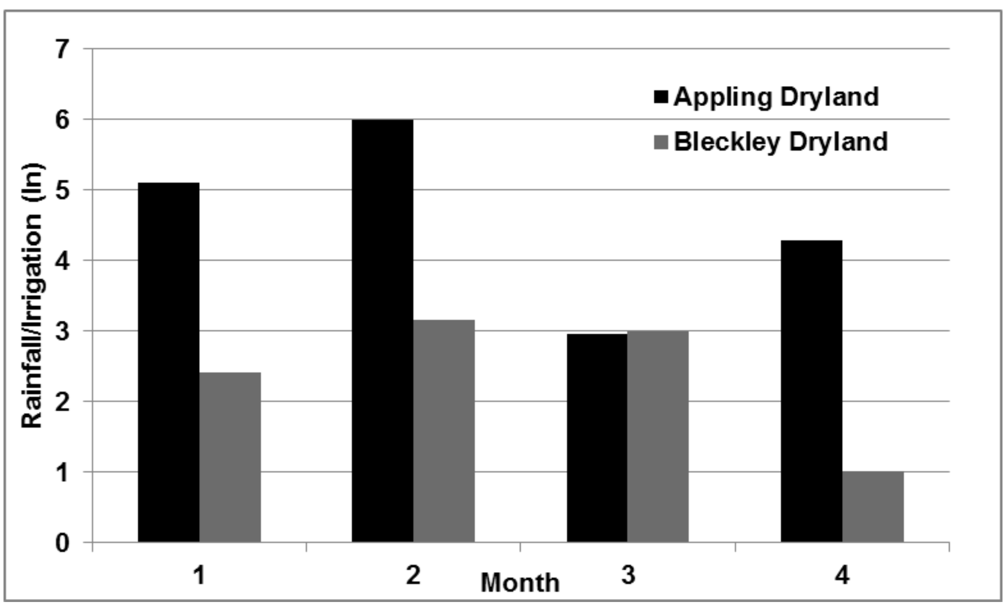

Figure 9. The amount of rainfall/irrigation recorded by rain gauges in both Appling Dryland (black) and Bleckley Dryland (grey) from the time that sensors were installed until cutout. The lower amount of rainfall recorded during month 4 is due to the sensors being uninstalled during that time.

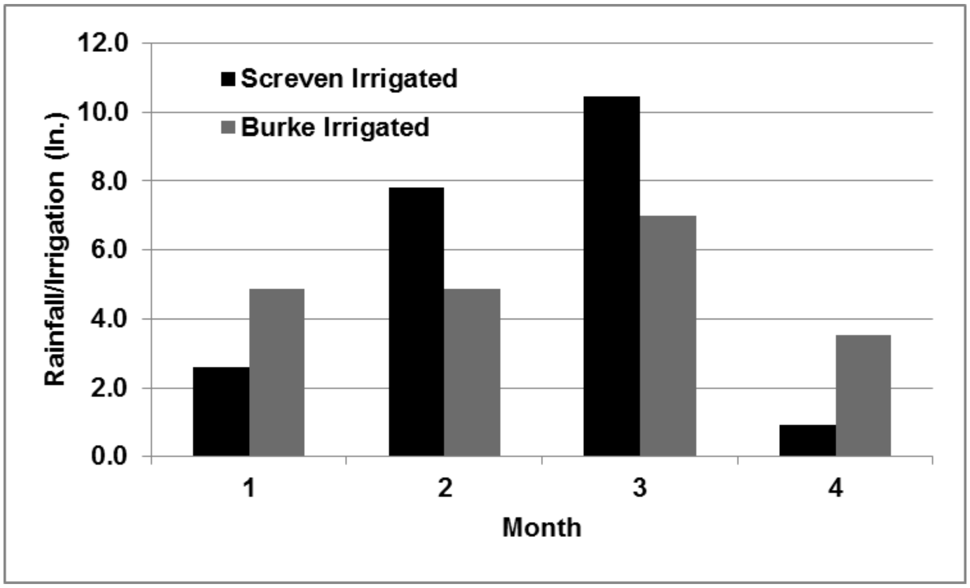

Figure 10. The amount of rainfall/irrigation recorded by rain gauges in both Screven Irrigated (black) and Burke Irrigated (grey) from the time that sensors were installed until cutout. The lower amount of rainfall recorded during month 4 is due the sensors being uninstalled during that time.

Acknowledgements

The authors gratefully acknowledge the funding support of the Georgia Cotton Commission and the partial funding of the College of Agriculture and Environmental Science Undergraduate Research Initiative. The authors also wish to express gratitude to Ricky Fletcher, Rad Yager, George Vellidis, John Gassett, Dustin Dunn, Anthony Black, Stan Jones, Sephus Willis, Judd Green,e and the growers that participated in the on-farm cotton variety trials.

References

Hiler, E. A., T. A. Howell. 1983. Irrigation Options to Avoid Critical Stress: An Overview. Limitations to Efficient Water Use in Crop Production. American Society of Agronomy.

Sheedy, M.D., J.E. Watson, E.C Martin. 1997. Economic Thresholds for Irrigation Management Decisions. Proceedings of the Beltwide Cotton Conference. 1: 593-597.

Simao, F.R., G.L. Ritchie, C.W. Bednarz. 2013. Cotton Physiological Parameters Affected by Episodic Irrigation Interruption. J. Agr. Sci. Tech. 3: 443-454.

Gwathmey, C.O., B.G. Leib, C.L. Main. Lint Yield and Crop Maturity Responses to Irrigation in a Short-Season Environment. 2011. J Cotton Sci. 15: 1-10.

Snowden, M.C., G.L. Ritchie, F.R.Simao, J.P. Bordovsky. Timing of Episodic Drought Can Be Critical in Cotton. Agron. J. 106: 452-458.

"USDA/NASS 2014 State Agriculture Overview for Georgia." Nass.usda.gov. USDA, 30 Nov. 2015. Web. 30 Nov. 2015.

Perry, C.D and E. Barnes. 2012. Cotton Irrigation Management for Humid Regions. Cotton Incorporated. http://www.cottoninc.com/fiber/agriculturaldisciplines/engineering/irrigation-management/cotton-irrigation-web.pdf

PHYSIOLOGICAL AND AGRONOMIC RESPONSES OF COTTON TO NITROGEN FERTILITY IN SOUTHERN GEORGIA

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Introduction

The cotton crop is highly responsive to nitrogen fertility, especially on coarse-textured soils of the coastal plain. Nitrogen deficiency negatively impacts yield by limiting a number of physiological processes important for plant growth and development. Although established N recommendations exist for lint yield goals up to 1500 lb/acre in Georgia, the near-constant release of improved, higher-yielding Upland cotton varieties necessitates a reevaluation of yield response to N fertility and of the underlying physiological processes that influence yield response to N management.

Materials and Methods

To assess the impact of N fertility rates on the physiology and yield of cotton, a field study was conducted in Tifton, GA during the 2015 growing season. The cotton cultivar DP1252 was planted in strip tilled plots on May 4 and at an average seeding rate of 3 seed per row ft, approximately ¾ in. planting depth, and 36 in. inter-row spacing. Plots were arranged according to a randomized complete block design with six N fertility treatments ranging from 0 lb N/ac to 150 lb N/ac. Table 1 lists each treatment and provides the amounts and timings of N application for each treatment. Plots were 4 rows wide, 30 ft long, and had 10 ft alleys between plots.

Seedcotton yields were determined by harvesting the center two rows of each plot using a spindle picker with a bagging attachment. Seedcotton weights were determined in the field for each plot using a scale positioned adjacent to the study area and were extrapolated to end-of-season seedcotton yield in lb/ac. In-season plant growth and physiological measurements included plant height, number of mainstem nodes per plant, number of mainstem nodes above the first position white flower (NAWF), net photosynthesis (P_N), chlorophyll content, and photosynthetic electron transport rate (ETR). Plant height, nodes, and NAWF were measured on multiple dates during the 2015 season on five plants per plot and an average value was determined for each plot prior to statistical analysis.

Gas exchange and fluorescence measurements were conducted on the fourth mainstem leaf node below the apical meristem using a Portable Photosynthesis System equipped with a Leaf Chamber Fluorometer. Midday (1200 to 1400 h) net photosynthesis (P_N) and light-adjusted chlorophyll fluorescence measurements were done using the following leaf chamber settings: flow rate was set to 500 µmol s^{-1}, block temperature was set to ambient air temperature, chamber CO_2 concentration was set at 400 ppm, and photosynthetic photon flux density (*PPFD*) = 2000 µmol m^{-2} s^{-1}. Steady state P_N was recorded roughly 60 s after the leaf was enclosed in the chamber. Photosynthetic electron transport rate (ETR) was estimated using chlorophyll fluorescence methods described elsewhere (Chastain et al., 2014). On the same leaves used for P_N and ETR measurements, chlorophyll content was determined by placing five 0.6 cm diameter leaf discs in 5 ml reagent grade ethanol for 2 weeks. During extraction, samples were kept in amber vials at 4°C. The absorbance of a 300 µl aliquot of each sample was determined at 649 nm (A_{649}) and 665 nm (A_{665}) using a 96 well plate reader. Chlorophyll a and b content were determined from the aforementioned absorbances according to the equations given in

Knudson et al. (1977), and the two concentrations were summed to obtain total chlorophyll content per cm^2 leaf area.

Means and standard errors for each treatment were calculated and graphs produced for each parameter of interest using SigmaPlot 13.0 Software. The effect of N rate on the aforementioned parameters and end-of-season fiber yield was assessed using one-way mixed effects ANOVA where block represented a random effect and N rate a fixed effect. Where significant main effects were observed, mean separation was performed using Fisher's protected LSD *post hoc* analysis at. Alpha = 0.05 for all analyses, and analyses were conducted using JMP Pro 12.

Table 1. A list of N fertility treatments (T1-T6) and associated description of the total N applied, N applied at planting, and side dress applied N for each treatment.

Treatment	Total lb N/ac	At Planting	Side Dress
T1	0	0 lb N/ac	0 lb N/ac
T2	75	25 lb N/ac	50 lb N/ac
T3	94	31 lb N/ac	63 lb N/ac
T4	112	37 lb N/ac	75 lb N/ac
T5	131	44 lb N/ac	87 lb N/ac
T6	150	50 lb N/ac	100 lb N/ac

Results and Discussion

The 0 N treatment (T1) had significantly lower yields than any other treatment. T2 through T6 produced seedcotton yields that were statistically the same (Figure 1). By July 7, plants in T1 were already significantly shorter and had fewer mainstem nodes than all other treatments (Figures 2 and 3). T1 attained a maximum height of 28 inches during the growing, whereas, the maximum height for the remaining treatments ranged from 39 in. for T3 to 42 in. for T6. Thus, vegetative growth was positively associated with higher N rates. NAWF was also strongly impacted by N rate (Figure 4). T1 had significantly lower NAWF than all other treatments during early flowering (July 7), and had reached cutout (NAWF < 3; Bednarz and Nichols, 2005) earlier than all other treatments. By August 17, net photosynthesis (Figure 5), electron transport rates through photosystem II, and chlorophyll content per cm^2 leaf area (Figure 7) all exhibited similar responses to N rate, where the lowest photosynthetic rates and chlorophyll contents were observed in the lowest N rate treatment (T1) and the highest photosynthetic rates and chlorophyll contents were observed at the highest N rates. Thus, N deficiency limited yields by decreasing overall plant growth and node development, hastening cutout, and limiting photosynthetic capacity. While this study illustrates that increasing N rate had a positive impact on the growth and physiology of the crop, increased vegetative growth, chlorophyll content, and photosynthetic ETR did not necessarily translate to differences in seedcotton yields for the treatments that received N rates ranging from 75 (T2) to 150 (T6) lb N per acre.

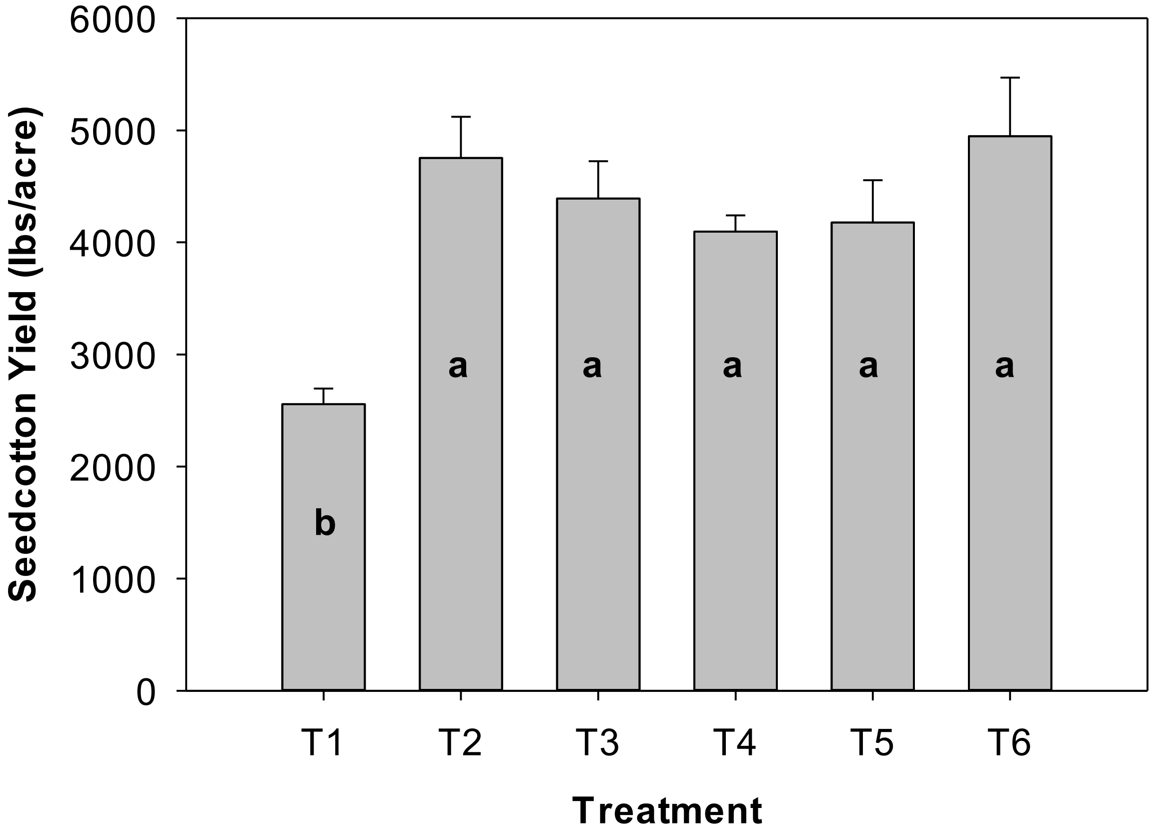

Figure 1. Seedcotton yields for N-Fertility Treatments T1 (0 lb N/ac), T2 (75 lb N/ac), T3 (94 lb N/acre), T4 (112 lb N/ac), T5 (131 lb N/ac), and T6 (150 lb N/ac) during the 2015 growing season in Tifton, GA. Values are means ± standard error (n = 4) and bars not sharing a common letter are significantly different ($P < 0.05$).

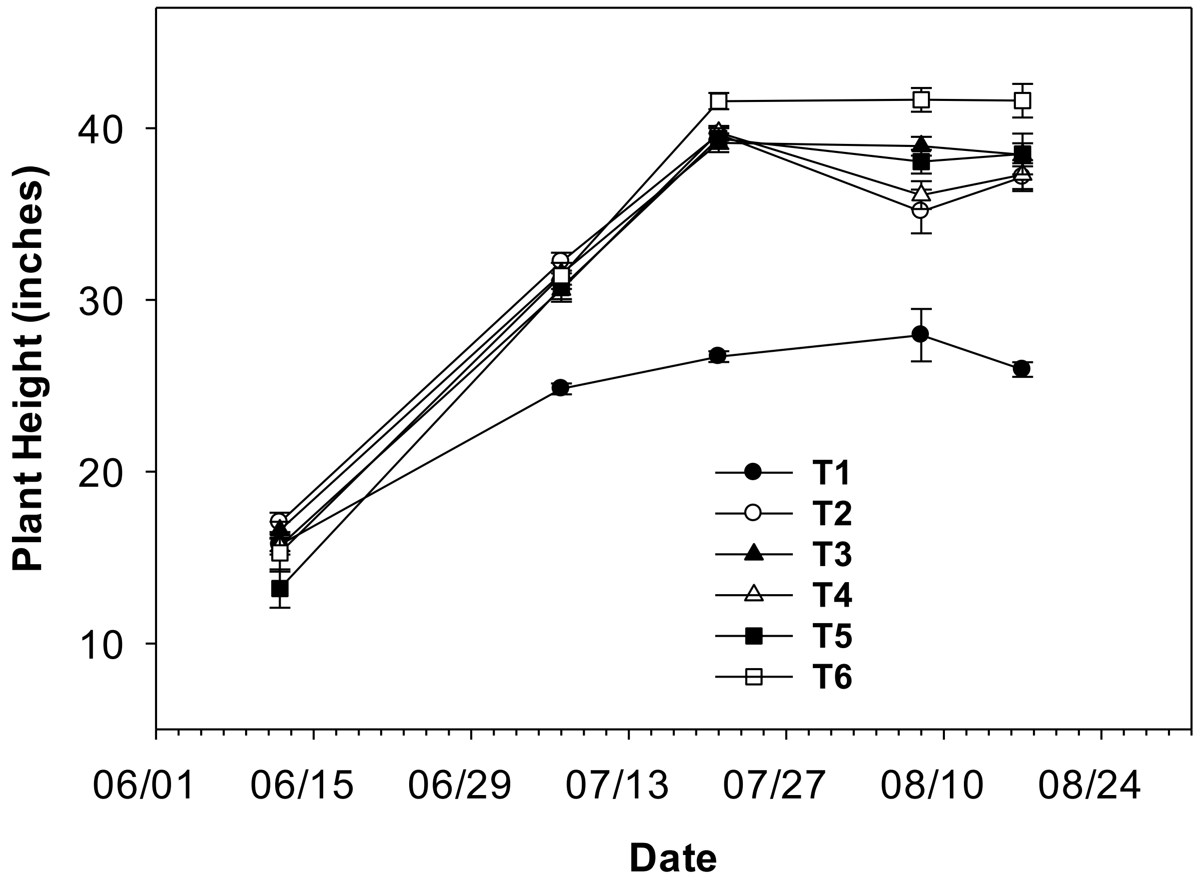

Figure 2. Plant height for N-Fertility Treatments T1 (0 lb N/ac), T2 (75 lb N/ac), T3 (94 lb N/ac), T4 (112 lb N/ac), T5 (131 lb N/ac), and T6 (150 lb N/ac) on five different sample dates throughout the 2015 growing season in Tifton, GA. Values are means ± standard error (n = 4).

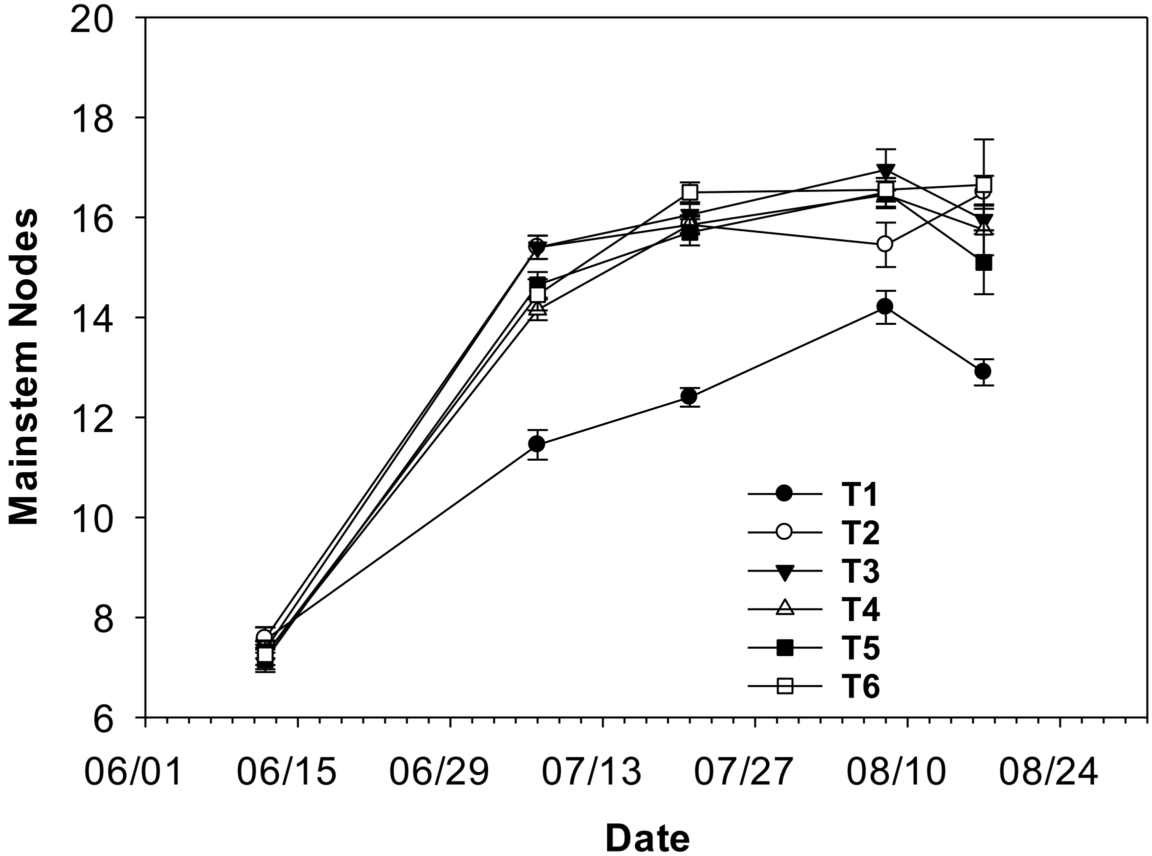

Figure 3. Number of mainstem nodes for N-Fertility Treatments T1 (0 lb N/ac), T2 (75 lb N/ac), T3 (94 lb N/ac), T4 (112 lb N/ac), T5 (131 lb N/ac), and T6 (150 lb N/ac) on five different sample dates throughout the 2015 growing season in Tifton, GA. Values are means ± standard error (n = 4).

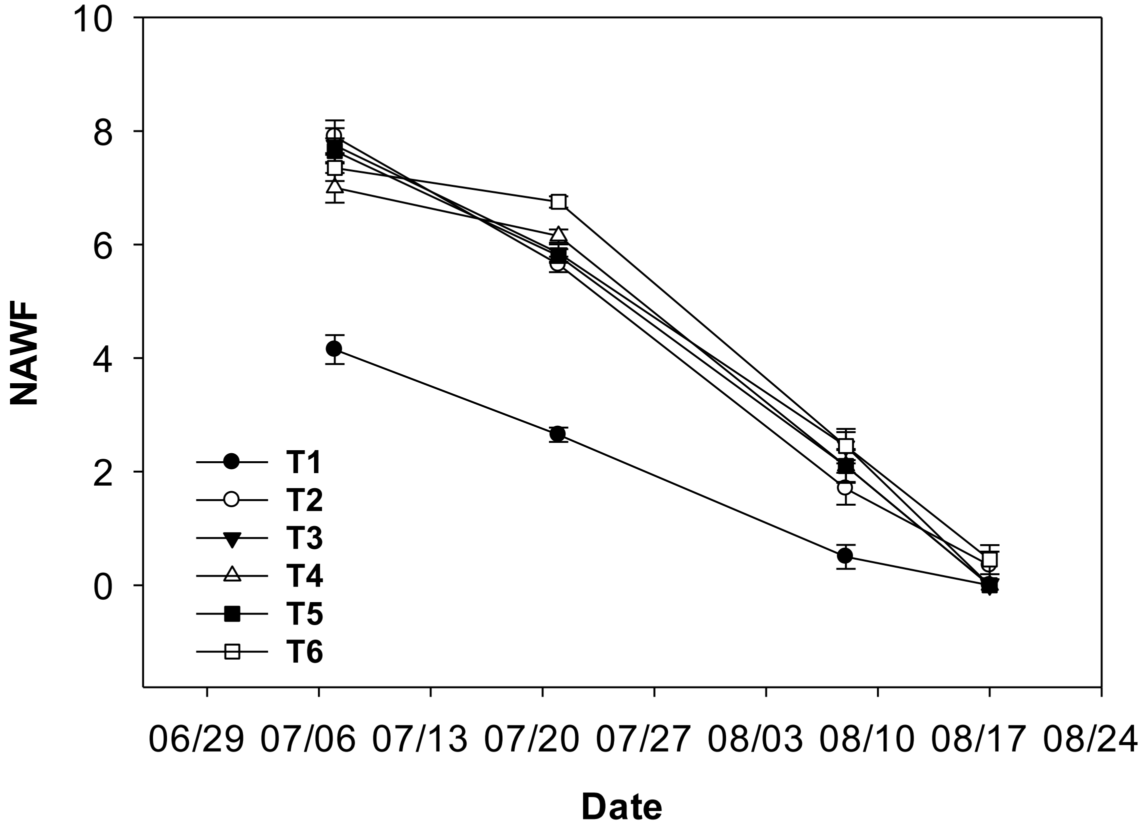

Figure 4. Number of mainstem nodes above the uppermost first position white flower (NAWF) for N-Fertility Treatments T1, T2, T3, T4, and T5, and T6 on four different sample dates during the 2015 growing season in Tifton, GA. Values are means ± standard error (n = 4).

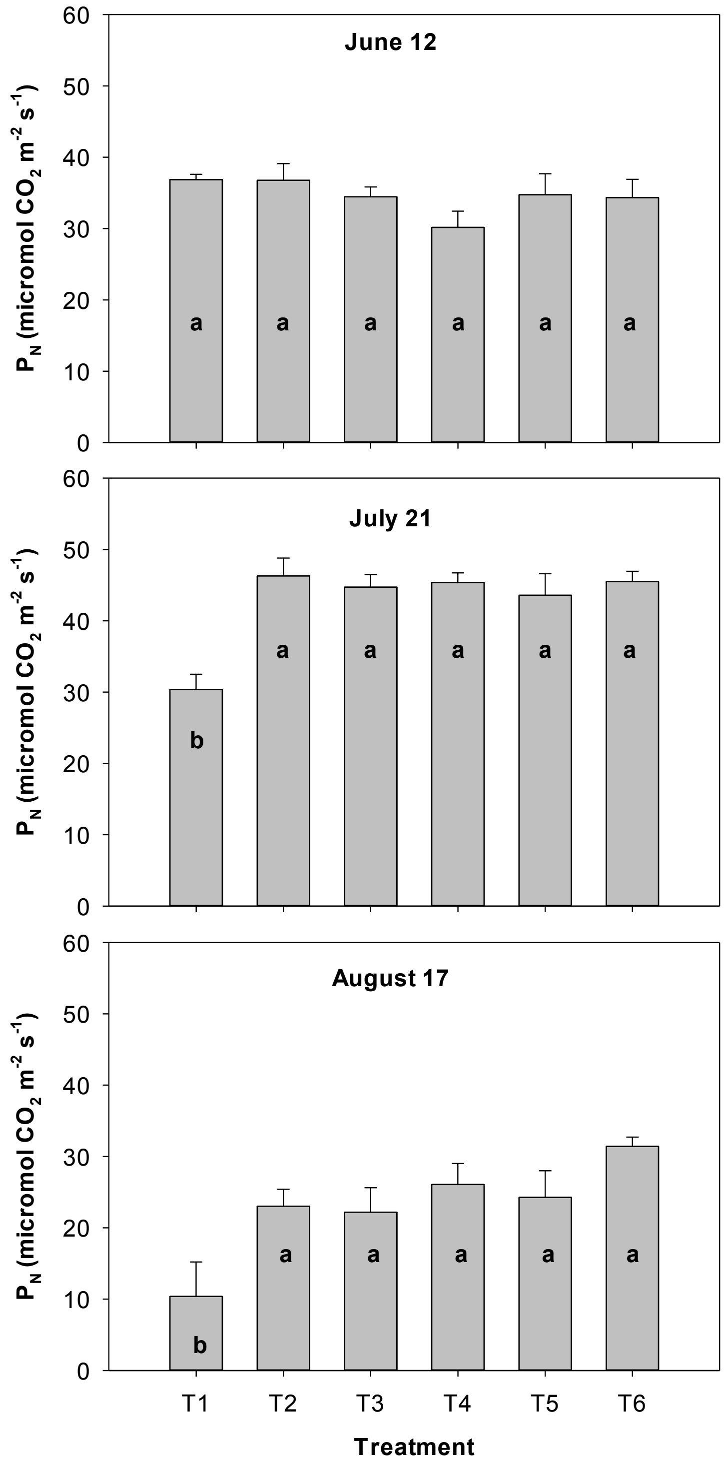

Figure 5. Net photosynthetic rates (P_N) for N-Fertility Treatments T1 (0 lb N/ac), T2 (75 lb N/ac), T3 (94 lb N/ac), T4 (112 lb N/ac), T5 (131 lb N/ac), and T6 (150 lb N/ac) on June 12, July 21, and August 17, 2015 in Tifton, GA. Values are means ± standard error (n = 4) and bars not sharing a common letter are significantly different ($P < 0.05$).

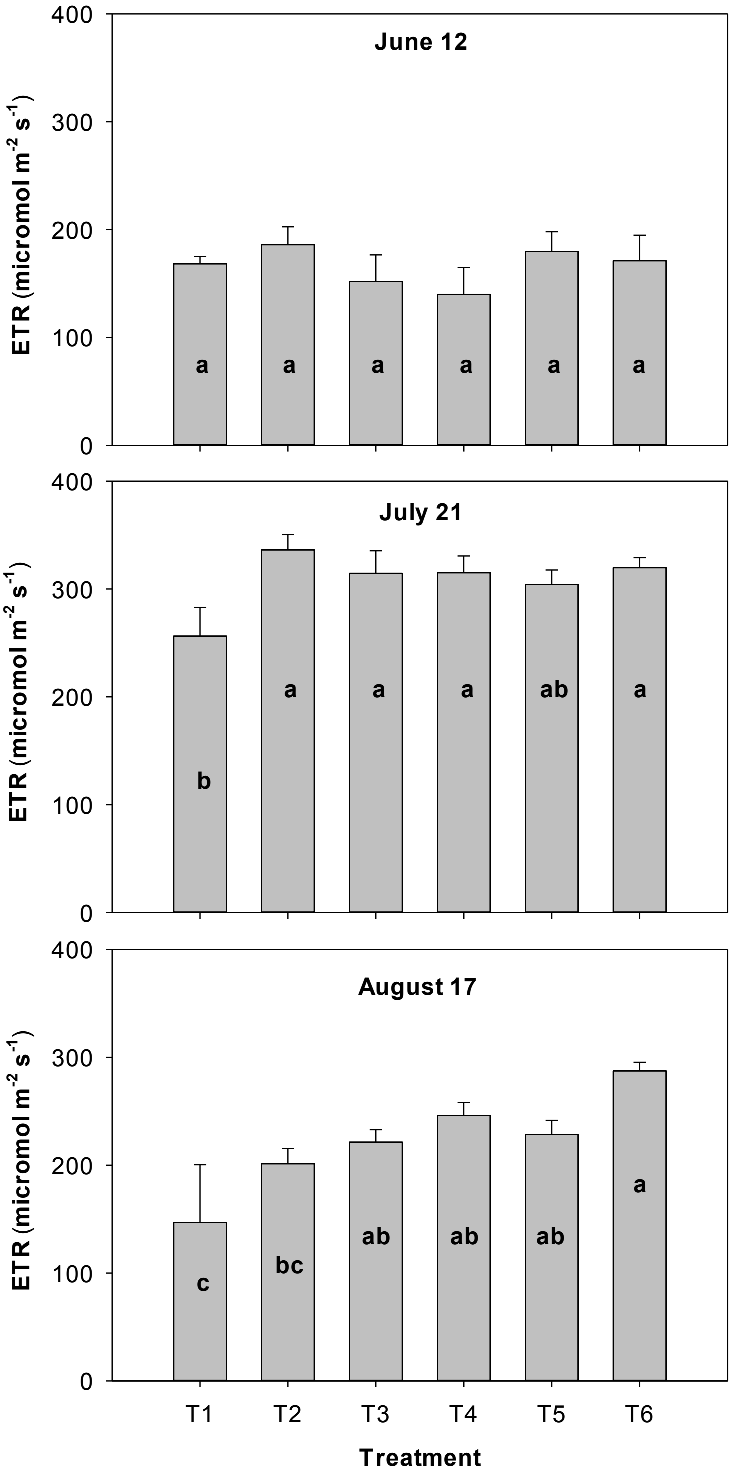

Figure 6. Photosynthetic electron transport rate (ETR) for N-Fertility Treatments T1 (0 lb N/acre), T2 (75 lb N/ac), T3 (94 lb N/ac), T4 (112 lb N/ac), T5 (131 lb N/ac), and T6 (150 lb N/ac) on June 12, July 21, and August 17, 2015 in Tifton, GA. Values are means ± standard error (n = 4). Bars not sharing a common letter within a sample date are significantly different (*P* < 0.05).

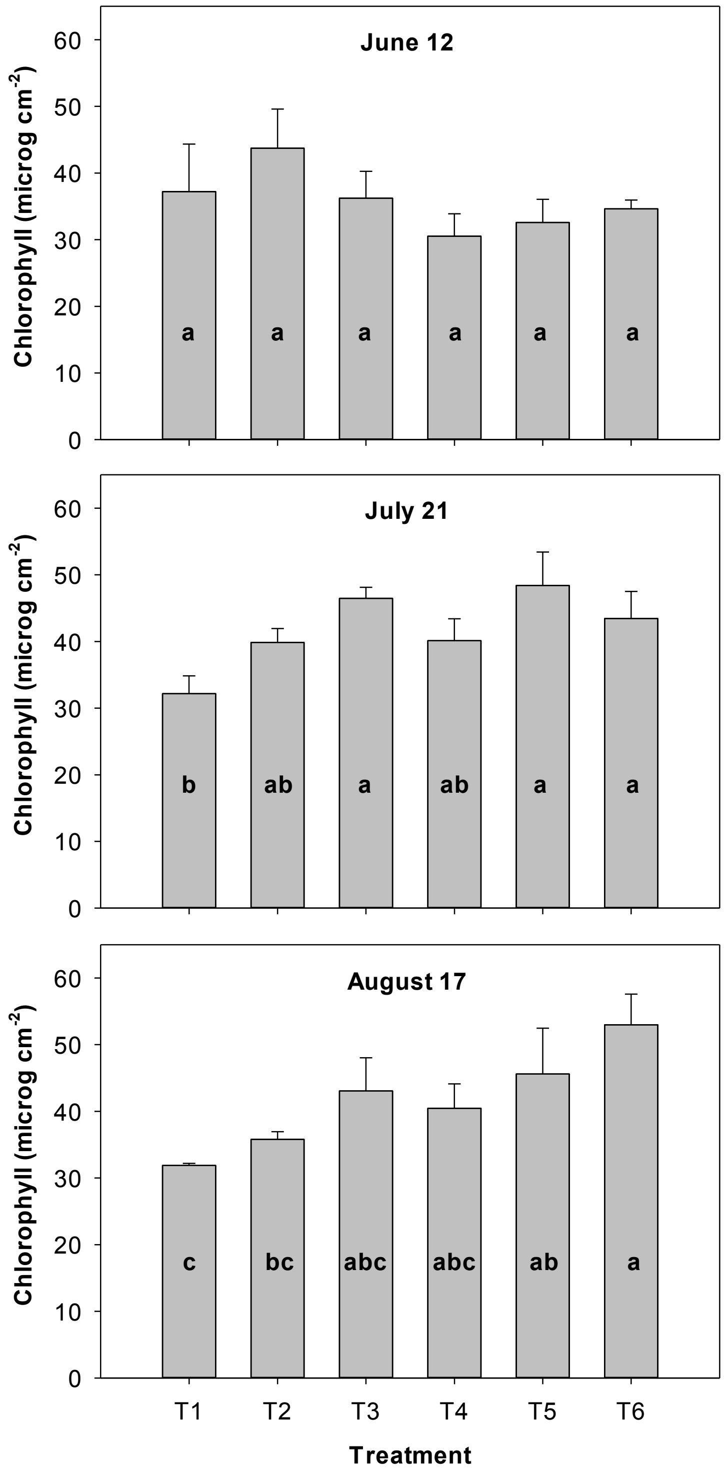

Figure 7. Total chlorophyll content for leaves sampled from N-Fertility Treatments T1 (0 lb N/ac), T2 (75 lb /ac), T3 (94 lb N/ac), T4 (112 lb N/ac), T5 (131 lb N/ac), and T6 (150 lb N/ac) on June 12, July 21, and August 17, 2015 in Tifton, GA. Values are means ± standard error (n = 4). Bars not sharing a common letter within a sample date are significantly different (P < 0.05).

Acknowledgements

The authors would like to thank the Georgia Cotton Commission, Cotton Incorporated, and the University of Georgia for support of this project.

References

Bednarz, C.W. and R.L. Nichols. 2005. Phenological and morphological components of cotton crop maturity. Crop Sci. 45: 1497-1503.

Chastain, D.R., J.L. Snider, G.D. Collins, J. Whitaker, C.D. Perry, and S.A. Byrd. 2014. Water deficit in field-grown *Gossypium hirsutum* primarily limits net photosynthesis by decreasing stomatal conductance, increasing photorespiration, and increasing the ratio of dark respiration to gross photosynthesis. J. Plant Physiol. 171: 1576-1585.

Knudson, L.L., T.W. Tibbitts, and G.E. Edwards. 1977. Measurement of ozone injury by determination of leaf chlorophyll concentration. Plant Physiol. 60:606-608.

WEED CONTROL IN DGT COTTON

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Introduction

The incidence of herbicide weeds emerging in the Southeast has increased the need for multiple mechanisms of action for successful cotton production. Utilized in combination with new and traditional cotton herbicides, cottonseed tolerant to dicamba/glufosinate/glyphosate (DGT) is currently marketed in Georgia. However, dicamba products for use for these seed have not been registered as of April 2016. However, research has continued to be conducted to establish the effectiveness of these technologies in combination with new dicamba formulations, such as Engenia by BASF. Even with DGT cotton, there are still no herbicide options available to farmers that provide season-long weed control when applied post-emergence (POST). Current cotton herbicide systems used to control many dicot and grass weed species and herbicide resistant weeds utilize preplant (PRE) dinitroanalines herbicides such as pendimethalin (Prowl 3.3EC) in combination with the diphenyl-ether fomesafen (Reflex). While these provide early season control, they are often used in combination with herbicide tolerant cotton, which allows for POST applications of contact herbicides such as glyphosate (Roundup Powermax) or glufosinate (Liberty), along with the residuals dimethenmid-P (Outlook), *S*-metolachlor (Dual Magnum), or acetochlor (Warrant). Glyphosate and ALS resistant Palmer amaranth are commonly found in Georgia, while sicklepod and morning glories are troublesome weeds in cotton production. Palmer amaranth, sicklepod, and morning glories can emerge throughout the growing season, can significantly reduce cotton yield, and are vigorous competitors with cotton for nutrients, sunlight, and moisture if emergence occurs within a few weeks of the crop. Comparisons for dicamba in crop application in combination with contact and residual herbicides with DGT cotton have not been evaluated. Therefore, studies were conducted using DGT cotton to evaluate weed control.

Materials and Methods

Field trials were conducted in 2015 at the University of Georgia Research and Education Center in Plains, Georgia. An experimental line of Monsanto DGT cotton was planted using a Monosem precision vacuum planter set to deliver 4.3 seed per foot of row. The experimental design was a randomized complete block with treatments replicated four times. Plots were two rows, 6 ft wide by 30 ft long, with a non-treated row on one side of each plot acting as a boarder for weed control checks (Figure 1).

Herbicide programs consisted of PRE, POST-1, and POST-2 application timings (Table 1). Cotton was planted on May 14, followed by PRE application. POST-1 treatments were applied to cotyledon- to 2-leaf cotton on May 29th, and POST-2 treatments were applied to 6- to 8-leaf on June 23rd. A non-treated control was included for comparison.
Cotton injury and weed control ratings were evaluated after applications, and throughout the season, using a scale of 0 (no injury) to 100% (complete death). Cotton stand counts and height measures were taken four times, cotton biomass at 96 days after planting (DAP), and Palmer amaranth stand counts were made twice. Weed control ratings were taken multiple times during the season, but only final ratings are presented. All plots were mechanically destroyed after final weed control ratings were taken in August.

Results and Discussion

There were no differences for cotton stand establishment at 6, 15, 26, and 96 DAP (data not shown). Overall stand ranged from 11 to 15 plants/m of row at 26 DAP, with the least stand in the non-treated control and Roundup at POST-1 only treatment. Stand remained consistent at 96 DAP. Cotton height at 96 DAP was reflected of the competition from weeds when no PRE treatment was applied (Table 1). No single treatment significantly affected height overall.

Data indicated significant differences in Palmer amaranth stands at 26 DAP (Table 1). The non-treated control had Palmer amaranth at 67 plants/m^2, while the Roundup only treatment at POST-1 had 22 plants/m^2. All other treatments had less than 2 plants/m^2 Palmer amaranth at 26 DAP. Weed control at 67 DAP was reflective of the herbicide treatments, and weed pressure was very high (Figure 1). When no residual herbicides were PRE applied, as in the boarder rows, Palmer amaranth, sicklepod, and morning glory species emerged throughout the growing season. However, by applying residual and contact herbicides in combination with each other at POST-1 and POST-2, weed control was very effective. These data indicate that utilizing DGT cotton can be effective at integrating multiple herbicide mechanisms of action to obtain season long weed control. Growers should be cautioned to not rely on a single herbicide for cottonweed control.


Figure 1. Dicamba and glufosinate-tolerant (DGT) cotton in 2015 at Plains, GA. Treatment consisted of Prowl 3.3EC plus Reflex PRE at planting, followed by Roundup Powermax plus Engenia plus Outlook POST-1. Picture taken 67 days after planting.

Table 1. Herbicide systems in dicamba[a] and glufosinate-tolerant (DGT) cotton in 2015 at Plains GA.

PRE[b]	POST-1[b]	POST-2[b]	Cotton height	Palmer amaranth Stand - June 9th	Palmer amaranth Jun 27	Palmer amaranth Aug 18	Sicklepod Jun 27	Sicklepod Aug 18	Tall morningglory Aug 18
			cm/plant	#/m²	%				
None	None	None	79 b	67 a	0 c	0 b	0 b	0 b	0 b
None	Glyphosate	None	132 a	22 b	20 b	0 b	97 a	50 b	0 b
Pendimethalin + fomesafen	Glyphosate + dicamba	None	122 a	0 a	99 a	99 a	99 a	99 a	99 a
Pendimethalin + fomesafen	Glyphosate + dicamba + dimethenamid	None	106 a	0 a	99 a	99 a	99 a	99 a	99 a
Pendimethalin + fomesafen	Glyphosate + dicamba + dimethenamid	Glufosinate + acetochlor	88 ab	0 a	99 a	99 a	99 a	99 a	99 a
Pendimethalin + fomesafen	Glufosinate + dimethenamid	Glyphosate + dicamba + acetochlor	104 a	0 a	99a	99 a	99 a	99 a	99 a
Pendimethalin + fomesafen	Glufosinate + glyphosate + *S*-metolachlor	Glufosinate + acetochlor	143 a	0 a	99 a	99 a	99 a	99 a	99 a
None	Glyphosate + dicamba + acetochlor	Glyphosate + dicamba + acetochlor	62 b	2 a	99 a	99 a	99 a	99 a	99 a
Pendimethalin + fomesafen	None	Glyphosate + glufosinate + dicamba + dimethenamid	118 a	0 a	98 a	99 a	99 a	99 a	99 a

[a]Formulations: dicamba – Engina, and dimethenamid-P – Outlook, by BASF; glufosinate – Liberty by Bayer Crop Sciences; fomesafen – Reflex by Syngenta; glyphosate – Roundup PowerMax, and acetochlor – Warrant, by Monsanto.
[b]PRE applied and cotton planted May 14, 2015; POST-1 applied May 29, 2015; POST-2 applied June 23, 2015.

Acknowledgements

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SELECTING THE MOST EFFECTIVE PRE HERBICIDE FOR COTTON

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Introduction

Glyphosate-resistant Palmer amaranth is controlled in cotton with well-timed glufosinate applications plus residual PRE and POST herbicides (Cahoon et al. 2015). Several PRE herbicides control Palmer amaranth and are recommended components of management systems (York 2015). Although essential, PRE herbicides sometimes injure cotton (Main et al. 2012). The objective of this research was to evaluate PRE herbicide combinations and rates as components of an overall management system to control Palmer amaranth while minimizing cotton injury.

Materials and Methods

The experiment was conducted in 2015 in Macon County and Moultrie. DP 1553 B2XF was planted at both locations. Treatments consisted of PRE herbicide combinations, listed in Table 1, and a non-treated check. Roundup PowerMax + Liberty at 32 + 32 oz/ac were applied POST 18 and 35 days after planting when Palmer amaranth averaged 4 inches tall and again 18 to 25 days after the second POST application. The experimental design was a randomized complete block with three or four replications based on location.

Table 1. Herbicide combinations and rates applied and Palmer amaranth control.

PRE herbicide option	Rate (fl oz/ac)	Palmer control 3 wk after treatment[a]	Palmer control at harvest[a]
Reflex + Warrant	12 + 32	97 ab	100 a
Reflex + Warrant	16 + 32	100 a	100 a
Warrant + Direx	48 + 16	90 bc	100 a
Warrant + Direx	48 + 16	92 abc	96 a
Warrant + Cotoran	48 + 32	97 ab	99 a
Reflex + Direx	12 + 16	93 b	98 b
Reflex + Direx	16 + 16	99 a	98 a
Reflex + Cotoran	16 + 16	94 ab	98 a
Brake F16	16	98 a	100 a
Cotoran + Caparol	32 + 32	85 c	91 b
No PRE			81 c

[a]Means followed by the same letter within a column are not different at P = 0.05.

Results and Discussion

Cotton Injury
No injury was noted with PRE herbicides at the Moultrie, GA location. At 14 days after planting at Macon, injury ranged from 2 to 9% with no differences among PRE herbicides (data not shown).

Palmer Control
The PRE herbicides were well activated. Just prior to the first POST application, control was at least 90% except with Cotoran + Caparol where control was only 85%. During early season,

Reflex + Warrant, Cotoran + Warrant, and Brake F16 were generally the most effective options. By harvest after sequential POST applications were made, control was complete with Reflex + Warrant and Brake F16 systems. Control of at least 96% was noted with Warrant + Direx, Reflex + Direx, and Reflex + Cotoran systems. Less control (91%) was noted with the Cotoran + Caparol system. However, control of all systems containing PRE herbicides was greater than that noted with the sequential POST system without a PRE.

Seed Yield

Yields from all systems including a PRE herbicide were similar at both locations (data not shown). Seed cotton yields from systems including PRE herbicides were 385 to 915 lb/A greater than the total POST program.

Acknowledgements

The authors would like to thank the Georgia Cotton Commission and Cotton Incorporated for support of this project.

Literature Cited

Cahoon, C.W., A.C. York, D.L. Jordan, W.J. Everman, R.W. Seagroves, L.R. Braswell, K.M. Jennings. 2015. Weed control in cotton by combinations of microencapsulated acetochlor and various residual herbicides applied preemergences. Weed Technol. 29:740-750.

Main C.L., J.C. Faircloth, L.E. Steckel, A.S. Culpepper, A.C. York. 2012. Cotton tolerance to fomesafen applied preemergences. J. Cotton Sci. 16:80-87.

York A.C. 2015. Weed Management in Cotton. Pages 80-130 in 2015 Cotton Information. N. C. State Univ. Coop. Ext. Serv. Publi. AG-417.

DICAMBA-BASED PROGRAMS IMPROVE PALMER AMARANTH CONTROL IN COTTON

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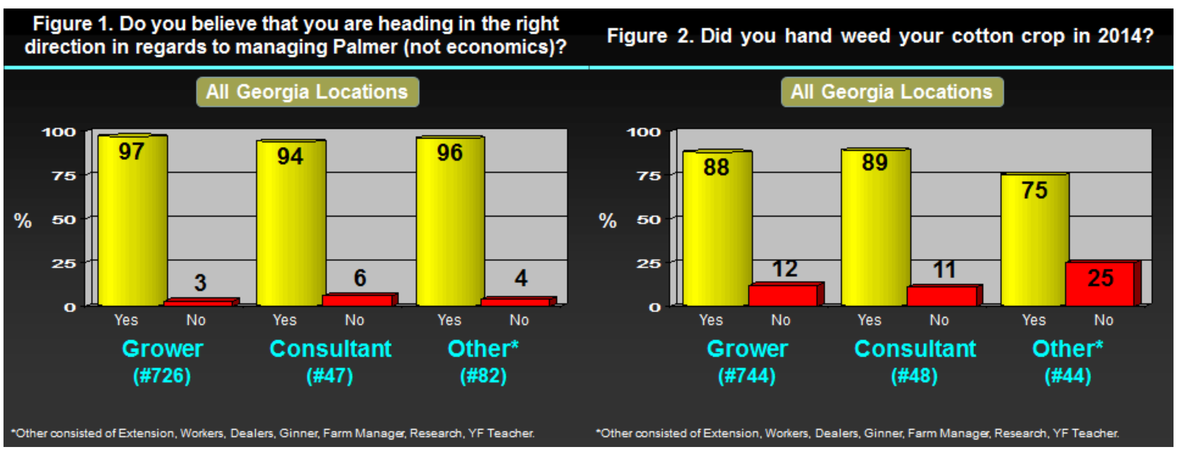
Introduction

A recent survey suggested Georgia growers are controlling glyphosate-resistant Palmer amaranth more effectively now than during the past decade (Figure 1). However, growers continue to invest significantly into managing this weed including hand weeding their cotton crop (Figure 2). Our objective was to determine if dicamba-based programs could potentially reduce hand weeding input cost compared to standard Roundup- and Liberty-based programs.



Materials and Methods

An experiment was conducted during 2015 in Garden Valley, Georgia. DP 1553 B2XF was planted during late April and four treatments were implemented. Each treatment consisted of the same herbicides applied PRE after planting (Reflex 12 oz + Warrant 3 pt/ac) and the same layby (Direx 1 qt/ac + MSMA 1 qt/ac + COC 1 qt/ac). Post treatments varied and included the following:

1. Liberty POST 1 and POST 2.
2. Liberty + Roundup PowerMax POST1 and POST 2.
3. Liberty + Roundup PowerMax + Warrant POST 1 and POST 2.
4. Roundup PowerMax + dicamba + Dual Magnum POST 1 and POST 2.

POST applications were made 21 and 15 days after planting with POST herbicide applications rates as follows: Liberty, 32 oz/ac; Roundup PowerMax, 32 oz/ac, Warrant, 3 pt/ac; Dual Magnum, 1 pt/ac and dicamba, expected 1X labeled rate.

Plot size included 4 rows by 1200 feet and the experimental design was a randomized complete block. The number of Palmer amaranth plants per plot was counted throughout the season.

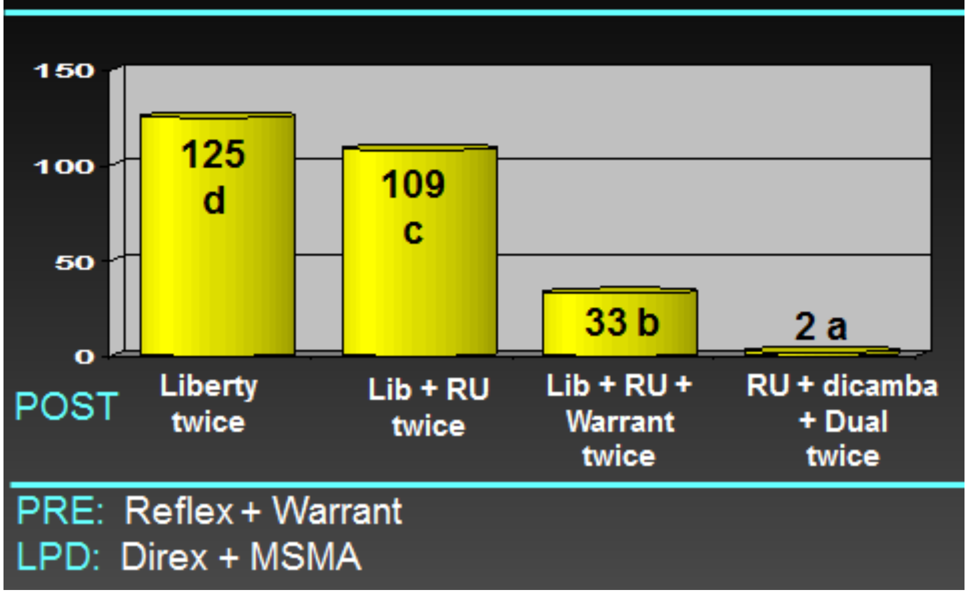
Results and Discussion

Visual Cotton Injury: Maximum injury of 5% was noted with the Liberty POST only system. Injury reached 13% with Liberty plus Roundup applied topically and 20% with Liberty plus Roundup plus Warrant. The dicamba-system caused a maximum of 15% visual injury in this experiment.

Palmer Control: During late-season just prior to harvest, the system containing sequential Liberty applications had 125 Palmer amaranth plants per acre present (Figure 3 below). The addition of Roundup with Liberty improved control slightly while the addition of Roundup plus Warrant with Liberty improved control much more effectively leaving only 33 plants per acre at harvest. The dicamba-system was more effective than any other system having only 2 plants per acre present at harvest.

Seed Yield: Yields from all systems were similar and ranged from 3695 to 3845 pounds per acre.

Figure 3. Large Acreage Study. Palmer Amaranth Per Acre at Harvest. Georgia. 2015.



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COTTON FOREIGN MATTER DETECTION USING HYPERSPECTRAL TRANSMITTANCE IMAGING

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Abstract

Cotton plays an important role in the U.S. national economy. This commodity can be contaminated by various foreign matter (FM) during harvesting and processing, leading to potential damage to textile products. Current sensing methods can only detect the presence of foreign matter on the surface of cotton, but cannot detect and classify foreign matter that is mixed with and embedded inside the cotton. This research focused on the detection and classification of common foreign matter hidden within the cotton lint by hyperspectral transmittance imaging in the spectral range from 950-1650 nm. Three cultivars of cotton and 10 common types of foreign matter were collected from the field, and the foreign matter were sandwiched by two thin cotton lint webs. The transmittance imaging platform was designed and optimized for the best performance of the transmittance mode. After acquiring images of cotton and foreign matter mixture, minimum noise fraction (MNF) rotation was utilized to obtain component images to assist visual detection and mean spectra extraction from a total of 141 bands. Linear discriminant analysis (LDA) and support vector machine (SVM) were performed for classification at the spectral and pixel level, respectively. Over 90% of the accurate classification rate was achieved for the spectral data. The preliminary results demonstrated that it was feasible to detect certain types of foreign matter that was buried within cotton using hyperspectral transmittance imaging.

Introduction

Foreign matter (FM) could affect the quality, appearance, and price paid for textile products, as well as the performance of ginning (Himmelsbach, Hellgeth et al. 2006). In the cotton industry, ginning is a very significant process to separate cotton fiber from seed and clean cotton lint. Ginners must balance the effect of trash removal and fiber damage depending on accurate identification of foreign matter (Anthony and Mayfield 1995). Since the ginning procedures and cotton quality assessment were affected directly by the content of FM, it is important to classify cotton FM to improve cotton grading and provide information for processing of cotton (Fortier, Rodgers et al. 2011).

Recently, many studies have been conducted for the identification of cotton foreign matter. Color imaging based method was widely used, due to its relative ease of use, high speed, and spatial information. For instance, the high volume instrument (HVI) employs color imaging to obtain trash percent area and trash particle count. Although HVI provides a relative measurement of cotton trash, it cannot give detailed information about the type of cotton trash (Foulk, McAlister et al. 2006), because the color camera can hardly classify foreign matter with similar color.

Spectroscopy could improve the classification performance by providing more spectral information. Fourier transform near-infrared (FT-NIR) spectroscopy was investigated to distinguish individual types of cotton trash from the fiber and achieved over 98% identification accuracy of cotton trash (Fortier, Rodgers et al. 2011, Fortier, Rodgers et al. 2012). Most foreign matter from machine harvesting, such as stem, bract, hull, and seed, are composed of lignin or protein, while cotton lint is mainly composed of cellulose (Himmelsbach, Hellgeth et al. 2006). Lignin, protein, and cellulose are made of molecular bonds such as CH_3, OH, and NH that have absorption bands in the NIR spectral range (Wakelyn, Bertoniere et al. 2006). The spectral range from ~780-1800 nm was optimal for distinguishing these foreign fibers, such as polypropylene and polyethylene materials, hairs and feathers (Yang, Li et al. 2009). However, spectroscopy cannot provide spatial information for image classification of FM with cotton.

Hyperspectral imaging can provide not only spatial information in the form of an image at a certain wavelength, but includes the spectral information of any pixels on the image. With both spatial and spectral information, the hyperspectral imaging technique has become an emerging analytical tool for quality detection (Zhang and Li 2014). A hyperspectral imaging system was developed to detect cotton lint foreign matter. The results showed that this system is effective to recognize and classify FM on the lint surface with the correct classification result of over 90% (Jiang and Li 2015a, Jiang and Li 2015b). For foreign matter hidden within the cotton, one study investigated the detection at the depth of ~1-6 mm in cotton using hyperspectral imaging based on reflectance mode (Guo, Ying et al. 2012). The results indicated that the detection was affected by the depth of the cotton lint. At the depths of ~3-4mm and ~5-6mm, the spectra of foreign matter were not clearly differentiated from the cotton.

Transmission characteristics of foreign matter are different from cotton lint due to decreasing level of the light energy after transmission. Using the optical transmittance mode to detect foreign matter could manage the issue of difficulties in inner foreign matter detection (Jia and Ding 2005). For the foreign matter that were buried in deeper depth in cotton, Jia and Ding utilized transmittance for their research on the detection of foreign matter buried in about 10 mm depth in cotton. Their experiment showed that transmittance could be an effective method to detect a wide range of foreign matter below the surface (Jia and Liu 2008). However, classification of cotton foreign matter using transmittance mode has not been reported.

Overall, the goal of this study was to explore the feasibility of hyperspectral imaging system using transmittance mode to detect and classify common types of foreign matter that were hidden inside the cotton lint at the spectral range of ~950-1650nm. The specific objectives of this study were to: (1) extract and compare the pure spectra of FM with the mixed spectra of FM and cotton; (2) classify cotton FM at the spectral and imaging domain.

Materials and Methods

Cotton Lint and FM samples

The lint from three cotton cultivars and ten types of foreign matter (Figure 1) were collected from the field during the 2014 harvest season on the University of Georgia Tifton Campus. The three cotton cultivars were Stoneville (ST) 6448, PhytoGen (PHY) 499, and Delta Pine (DP) 1252. The botanical FM included stem, seed coat, seed, hull, bract, bark and green leaf, which were manually selected from the seed cotton and ginned cotton rash. The non-botanical FM contained twine, paper, and plastic package, which were mixed with the lint during machine harvesting and packaging process.

When foreign matter were hidden inside the cotton layers, it was difficult to find them by naked human eyes, so the size of the FM was purposely prepared larger than typical FM found in lint. Stem, bark and twine were clipped to about 10 mm in length, and hull, bract, green leaf, paper and plastic package were cut into a square shape with about 10 mm in length. Seed coat and seed were kept their original size and shape.

To obtain the pure spectra of each type of FM and the spectra of the FM when they are mixed with lint, there were two methods to prepare samples. To extract pure spectra of the FM, four replicates of nine types of FM were prepared except plastic package, because the camera was saturated with the light passing through the thin plastic package directly. A black paper mask (240×200 mm) with four very small rectangular holes (~1-1.5×5 mm) was made to hold the foreign matter, with FM fully covering the holes. For lint with FM inside, 30 replicates of FM and 60 replicates of thin lint web (~10-12×12-14cm in shape, ~6-10mm in thickness, ~0.5-0.8g in weight) were made by hand. To avoid the effect of other unknown FM and cotton unevenness, the lint webs were cleaned and disentangled manually. For mixed samples, ten types of FM were sandwiched between two lint webs.

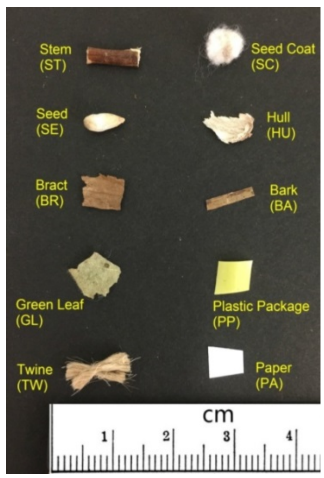

Figure 1. Ten types of foreign matter

Hyperspectral Transmittance Imaging System

A liquid crystal tunable filter (LCTF) based shortwave infrared (SWIR) hyperspectral imaging system developed by the Bio-Sensing and Instrumentation Lab at the University of Georgia was utilized to acquire images of FM and cotton using transmittance mode (Figure 2). The system consisted of a hyperspectral imaging subsystem (HIS), an illumination unit and an objective table. The HIS was integrated by a LCTF (LNIR 20-HC-20, Cambridge Research & Instrumentation, Cambridge, MA, USA), an indium gallium arsenide (InGaAs) SWIR camera (SU320KTS-1.7RT, Goodrich, Sensors Unlimited, Inc., Princeton, NJ, USA) combined with a near infrared lens (SOLO 50, Goodrich, Sensors Unlimited, Inc., Princeton, NJ, USA) (Wang, Li et al. 2012b). The imaging procedure was controlled by an in-house built LabVIEW program using a computer (Intel® Pentium® D Processor, 4 GB DDR3, Windows 7) via the Camera Link (Wang, Li et al. 2012a). To provide a wide spectrum illumination, a halogen floodlight (Portfolio® 50W T4, L G Sourcing, Inc., NC, USA) was supplied by adjustable direct current (DC). To obtain transmittance images, the sample was held by a floated borosilicate glass plate (BOROFLOAT® 33, thickness = 2.00 mm, Home Tech SCHOTT North America, Inc., Louisville, KY, USA) of the objective table above the halogen light. The glass plate has over 90% transmission in near infrared spectral range. To make the cotton lint web uniform for acquiring better quality images, the sample was pressed by the same type of glass plate and four wood blocks were placed in four corners to increase cotton uniformity. The weight of each glass plate was 200 g and the weight of each wood block was 100 g. The total weight on top of the sample was 600 g. The FM with the black mask were clamped with the two glass plates to ensure the same condition of illumination as the mixed samples.

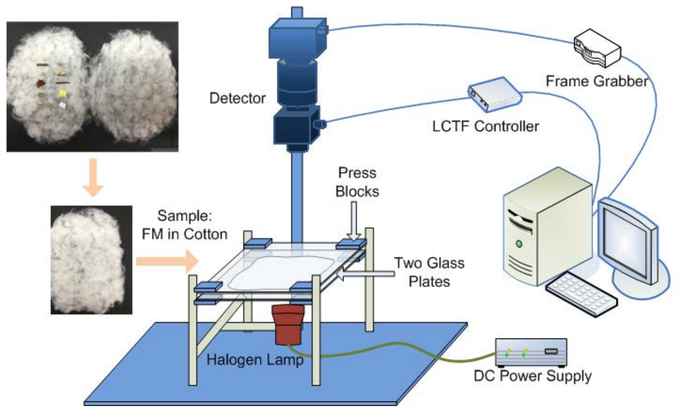

Figure 2. Hyperspectral transmittance imaging system

All samples were scanned from the spectral range of 950 to 1650 nm with a 5 nm spectral interval. The samples were kept in an enclosed chamber to avoid interference from the ambient light. The light was powered under the condition of 24W and 12V. The distance from the lens of the camera to the button glass surface was 875 mm. Figure 3 shows the principles of hyperspectral imaging. After scanning a sample, a three-dimensional (x, y, λ) image cube was constructed with both spatial (320×256 pixels) and spectral data (141 wavelength bands). The spatial information of x and y can form an image at a certain wavelength and a pixel in the 3D image cube represents a spectrum.

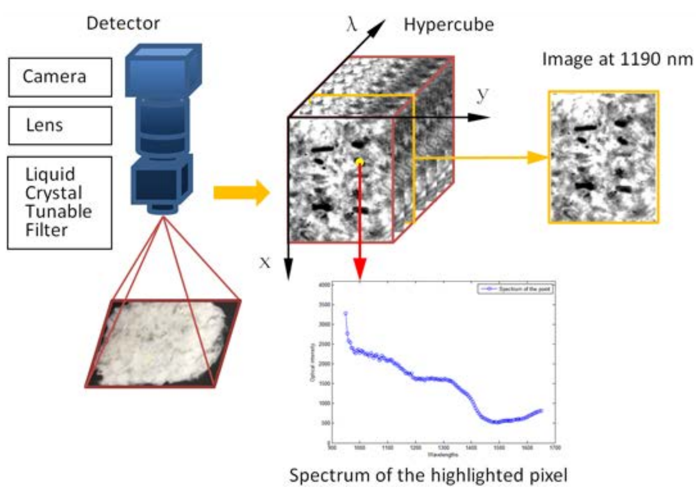

Figure 3. The principles of hyperspectral imaging

The acquired transmittance images were calibrated using flat field correction algorithm (Equation 1) implemented in Interactive Dynamic Language (IDL4.7, Exelis Visual Information Solutions, Boulder, CO, USA) (Wang, Li et al. 2012c). The bright images were acquired by replacing the sample with polytetrafluoroethylene (PTFE) Teflon plate (300×165×13.30 mm) between the two glass plates, and dark images were acquired by covering the lens of the camera (Coelho, Soto et al. 2013, Huang, Wan et al. 2013, Wang, Li et al. 2013). The relative transmittance intensity value I_R was calculated by:

$I_R = 4095*(I_T - I_D)/(I_B - I_D)$. (1)
I_T: pixel intensity of the transmittance image of a sample
I_D: pixel intensity of the dark image I_B: pixel intensity of the bright image

The coefficient 4095 is the maximum intensity that the image can express (12-bit image). The bright and dark images were acquired for every 5 samples.

MNF Rotation and Spectra Extraction

Before data processing, images were cropped into 180×250 pixels in order to remove the large amount of noise around the border caused by mismatching of the raw image and reference images during flat field correction. Minimum noise fraction (MNF) rotation is an algorithm that can reduce the spectral dimension and de-noise in the spatial dimension for hyperspectral images (Xu, Wei et al. 2013). This method separates signal and noise of the hyperspectral image before performing the rotation, thus improved image quality and features can be obtained with MNF components (Lu 2003).

For the images of mixed samples, prior to performing minimum noise fraction (MNF) rotation, the band of the first wavelength 950 nm was removed from the cube, because the band contained unusually high noise values. The 180×250×140 image cube of sample was processed by MNF rotation to assist visual detection and region-of-interest (ROI) extraction, because of difficulties in recognition of foreign matter within cotton. One of MNF component images that showed best contrast between the FM and lint would be selected. Based on this MNF component image, the ROIs of FM and lint were extracted manually, and then mapped on the original image cube to obtain the mean spectra. For the images of FM with the black mask, the mean spectra were directly extracted manually using ROIs method.

After extracting the spectra, normalization was performed to define the relative transmittance in the range of 0-100%. It was done by dividing the original relative intensity at each band by the maximum intensity value found in the whole spectra sets, including the spectra of FM and FM mixed with cotton.

The software ENVI 4.7 (ITT Visual Information Solutions, Boulder, CO, USA) was employed to conduct image cropping, band removal, MNF rotation, ROI selection, and mean spectra extraction of ROIs. For spectra normalization, MATLAB 2014 (The MathWorks Inc., Natick, MA, USA) was utilized to perform the algorithm.

Classification

Linear discriminant analysis (LDA) was employed to classify FM with cotton lint using mean spectra with full wavelengths of a total of 330 samples (30 replicates of 10 types of FM and cotton lint). The discrimination performance was evaluated by the percentage of samples that were correctly classified using the leave-one-out cross-validation. LDA was performed in SAS (SAS 9.4, SAS Institute Inc., Cary, NC, USA).

Results and Discussion

Spectra Extraction

After acquiring and cropping images, the component images were generated by MNF rotation of raw hyperspectral images. In Figure 4, taking the color image (Figure 4a) of FM without covering lint web as visual comparison, the FM on the transmittance image (Figure 4e) at 1200nm were not clearly identifiable. After MNF rotation, the first three MNF component images (Figure 4b, c, and d) revealed more effective information for foreign matter, especially component 1 (C 1). Thresholding was utilized to enhance the visual detection (Figure 4f) of the C 1 image using the gray value of 210. Most of the FM were segmented from the lint. Based on this result, ROIs of each type of FM were selected from the component 1 image (Figure 4g), which were marked by different colors, and then mapped on the original hyperspectral images (Figure 4h) to obtain the mean spectra. For the images of FM without cotton, mean pure spectra were obtained directly by ROIs method.

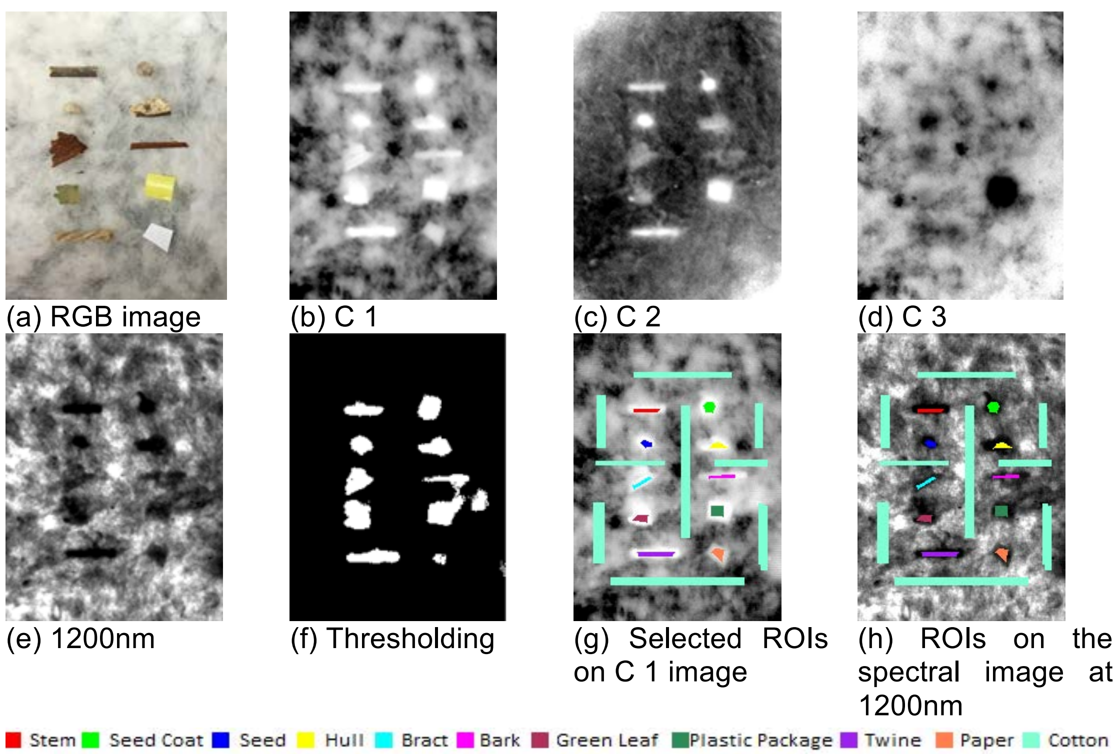

Figure 4. MNF component images and ROIs extraction

After spectra extraction, the maximum I_R was found to be 6946. The normalization region was defined to [0 1], by selecting 7000 as the maximum intensity. The normalized relative transmittance T_R (%) was generated by:

$T_R = I_R/70.$ (%)

Figure 5 showed the mean pure spectra and the mean mixed spectra of each type of foreign matter with the error bar. For stem, seed coat, seed, hull, bark and twine, the intensity of the spectra of mixed samples was higher than that of the pure FM spectra, whereas the cotton layer decreased the spectral intensity for other FM. In general, stem, seed coat, seed, hull, bark, and twine were thicker than the other types of FM and had high density that light can hardly pass through, since they almost completely blocked the light when they were placed on the black mask. In contrast, more light was scattered and reflected by cotton layer around the FM when they were placed between thin cotton lint webs, resulting in higher intensity of the spectra. For thinner FM, more light can pass through FM and the transmitted light was affected by cotton layers transmitted and scattering light. As a result, the spectra intensity of bract, green leaf and paper in cotton was lower than that of FM examined individually without cotton.

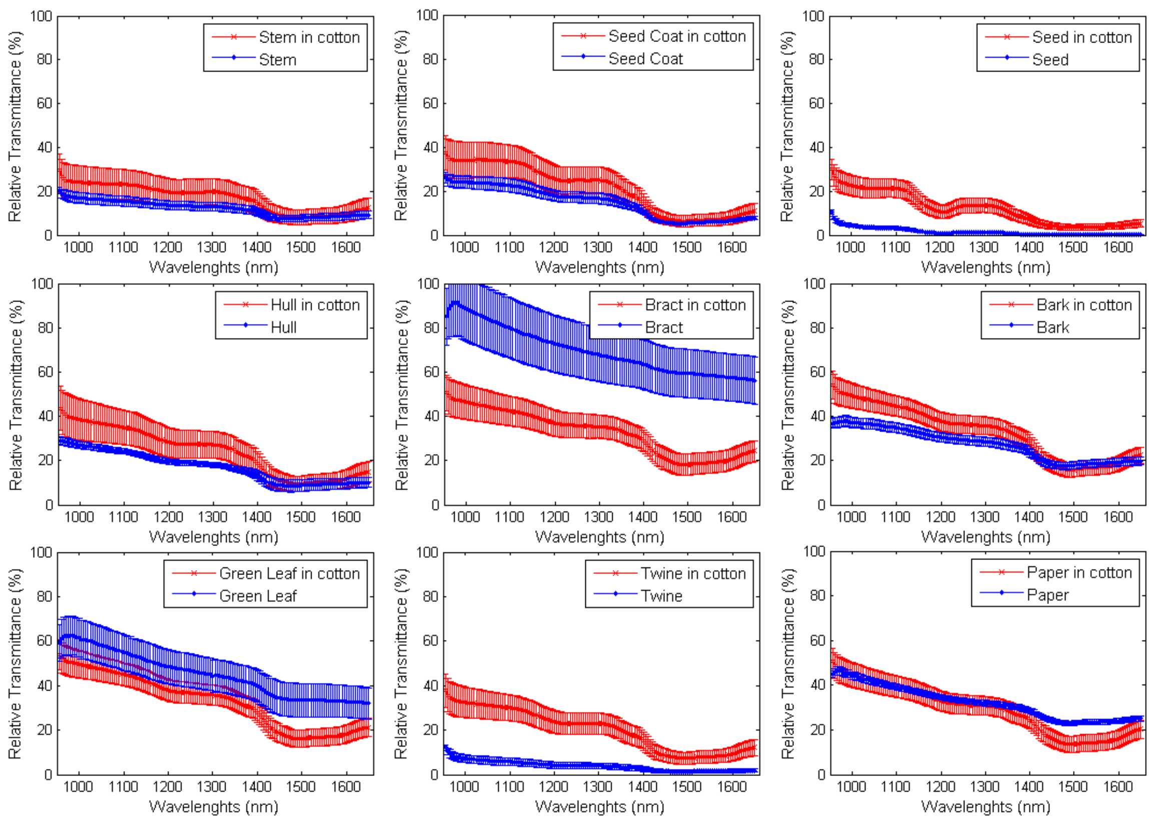

Figure 5. Mean spectra of FM and FM mixed with cotton (error bars indicate standard deviation)

The spectra of most FM had the same trend as the spectrum of cotton, because they were affected by the cotton lint when they were sandwiched between cotton webs (Figure 6). For plastic package, seed, and seed coat, their spectra had strong absorption around 1200 nm. In the future work, the band 1200 nm could be a key feature to analyze. For the spectra of bark and bract, they were pretty close to each other, because they had the same chemical content, similar appearance and thickness.

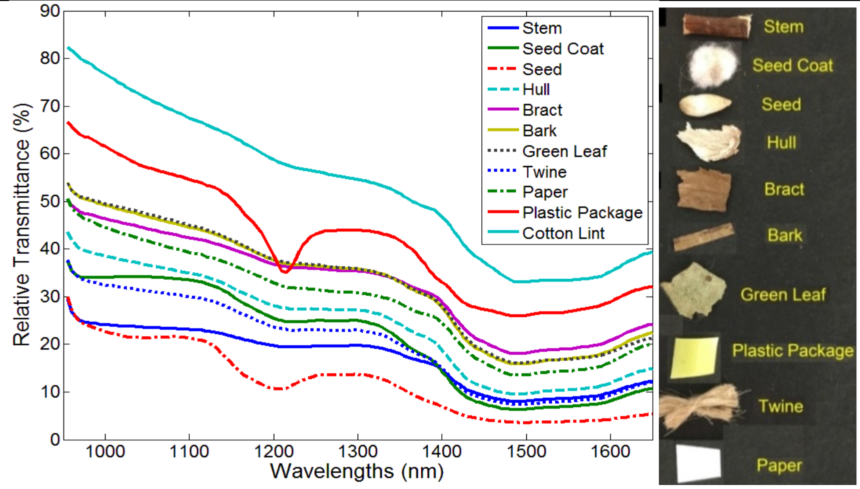

Figure 6. Mean spectra of FM in cotton

Classification at Spectral Level

LDA was used to classify various FM mixed with cotton lint based on their spectra. Figure 7 showed the results of classification for each type of foreign matter in cotton lint. For botanical FM, the lowest classification rates were 70% and 76.67% for bark and bract, respectively, because of their similarities. For stem and hull, the classification results were 83.33% and 86.67%, respectively, since they were both plant tissues with similar structure at the cell level. Green leaf and seed coat had distinct color and thickness, resulting in 90% and 96.67% of correct classification rate, respectively. For non-botanical FM, paper was mostly correctly classified (96.67%) with only one sample being misclassified into stem. The other two non-botanical types achieved 100% classification accuracy. Overall, the average classification rate was 90.91% including cotton lint.

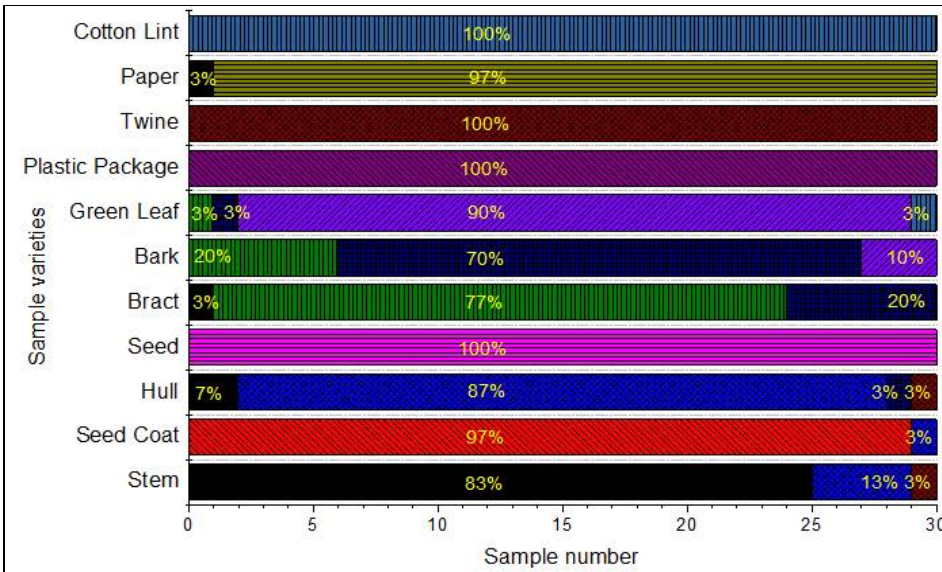

Figure 7. Spectral classification

Conclusions

This study provided preliminary results of using hyperspectral transmittance imaging to detect and classify ten common types of foreign matter that were sandwiched between cotton lint webs. The MNF component image after thresholding demonstrated good separation between FM and cotton lint when the FM were hidden inside the cotton lint. Correct classification result was 90.91% at the spectral level. The preliminary results demonstrated that it was feasible to classify FM using hyperspectral transmittance imaging, when the thickness of cotton sample was less than 5mm. There were some limitations of this work. The size of the FM used in this study was relatively larger than those found in ginned lint. In addition, image quality was significantly affected by the uniformity of cotton layer that was prepared manually. In future studies, the experiment parameters, as mentioned above, will be optimized.

References

Anthony, W. S. and W.D. Mayfield. 1995. Cotton Ginners Handbook, DIANE Publishing.

Coelho, P. A., M.E. Soto, S.N. Torres, D.G. Sbarbaro, and J.E. Pezoa. 2013. Hyperspectral Transmittance Imaging of the Shell-Free Cooked Clam Mulinia Edulis for Parasite Detection. J. Food Eng. 117: 408-416.

Fortier, C., J. Rodgers, J. Foulk, and D. Whitelock. 2012. Near-Infrared Classification of Cotton Lint, Botanical and Field Trash. J. Cotton Sci. 16: 72-79.

Fortier, C. A., J.E. Rodgers, M.S. Cintrón, X. Cui, and J.A. Foulk. 2011. Identification of Cotton and Cotton Trash Components by Fourier Transform near-Infrared Spectroscopy. Text. Res. J. 81: 230-238.

Foulk, J. A., D. Mcalister, and K. Kulasekera. 2006. Detecting the Cotton Trash Particle Size Distribution in Mill Laydown Using Hvi™ Trashmeter Software. *J. Text. Apparel Tech. Manag.* 5: 1-11.

Guo, J., Y. Ying, X. Rao, J. Li, Y. Kang, and Z. Shi. 2012. Detection of Trashes in Combed Cotton Using Hyper-Spectral Images. T. Chinese Soc. Agr. Mach. 43: 197-203.

Himmelsbach, D. S., J.W. Hellgeth, and D.D. Mcalister. 2006. Development and Use of an Attenuated Total Reflectance/Fourier Transform Infrared (Atr/Ft-Ir) Spectral Database to Identify Foreign Matter in Cotton. J. Agr. Food Chem. 54: 7405-7412.

Huang, M., X. Wan, M. Zhang, and Q. Zhu. 2013. Detection of Insect-Damaged Vegetable Soybeans Using Hyperspectral Transmittance Image. J. Food Eng. 116: 45-49.

Jia, D.-Y. and Z. Liu. 2008. Novel Method for Detection of Similar Objects Based on Transmission/Reflection Imaging. Opto-Electronic Eng. 6: 012.

Jia, D. and T. Ding. 2005. Analysis of Some Influence Factors of Transmission Imaging System for Detection of Foreign Material Buried in Cotton. T. Chinese Soc. Agr. Mach. 36: 65-69.

Jiang, Y. and C. Li. 2015a Mrmr-Based Feature Selection for Classification of Cotton Foreign Matter Using Hyperspectral Imaging. Comput. Electron. Agr. 119: 191-200.

Jiang, Y. and C.Y. Li. 2015b. Detection and Discrimination of Cotton Foreign Matter Using Push-Broom Based Hyperspectral Imaging: System Design and Capability. Plos One 10: 18.

Lu, R. 2003. Detection of Bruises on Apples Using near-Infrared Hyperspectral Imaging. T Amer Soc. Agr. Eng. 46: 523-530.

Wakelyn, P.J., N.R. Bertoniere, A.D. French, D.P. Thibodeaux, B.A. Triplett, M.-A. Rousselle, W.R. Goynes Jr, J.V. Edwards, L. Hunter, and D.D. Mcalister. 2006. Cotton Fiber Chemistry and Technology. Boca Raton, FL, CRC Press.

Wang, H., C. Li, and M. Wang. 2013. Quantitative Determination of Onion Internal Quality Using Reflectance, Interactance, and Transmittance Modes of Hyperspectral Imaging. T ASABE 56: 1623-1635.

Wang, W., C. Li, E.W. Tollner, and G.C. Rains. 2012a. Development of Software for Spectral Imaging Data Acquisition Using Labview. Comput. Electron. Agr. 84: 68-75.

Wang, W., C. Li, E.W. Tollner, G.C. Rains, and R.D. Gitaitis. 2012b. A Liquid Crystal Tunable Filter Based Shortwave Infrared Spectral Imaging System: Calibration and Characterization. Comput. Electron. Agr. 80: 135-144.

Wang, W., C. Li, E.W. Tollner, G.C. Rains, and R.D. Gitaitis. 2012c A Liquid Crystal Tunable Filter Based Shortwave Infrared Spectral Imaging System: Design and Integration. Comput. Electron. Agr. 80: 126-134.

Xu, L., X. Wei, X. Zhou, D. Yu, and J. Zhang. 2013. Study on Identification Method of Foreign Fibers of Seed Cotton in Hyper-Spectral Images Based on Minimum Noise Fraction. In: Computer and Computing Technologies in Agriculture VI. Springer: pp.166-176.

Yang, W., D. Li, X. Wei, Y. Kang, and F. Li. 2009. Selection of Optimal Band for Detecting Foreign Fibers in Lint Cotton Using Spectroscopic Analysis. T. Chinese Soc. Agr. Eng. 25: 186-192.

Zhang, H. and D. Li. 2014. Applications of Computer Vision Techniques to Cotton Foreign Matter Inspection: A Review. Comput. Electron. Agr. 109: 59-70.

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EFFECTS OF ALTERNATIVE COVER CROP STRATEGIES ON CONSERVATION BIOLOGICAL CONTROL IN COTTON

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Overview

Promoting populations of natural enemies and pollinators is an important component of managing agricultural systems. Natural enemies are beneficial insects that provide a biological service by preying on insects that are a nuisance in crop production. In this yearlong study, different cover cropping treatments, living and dead mulches, were evaluated for their ability to increase natural enemy abundance in cotton production. Cover crops have proven to aide in weed suppression, maintain soil fertility, and prevent erosion (Bond & Grundy, 2001). However, there is a need to further understand the complex interactions that accompany the use of cover crops, specifically between the insects different mulches harbor. Prior studies have used different mixtures of cover crops and evaluated their effectiveness based on prey and predator populations (Tillman et al., 2004), further study is needed to integrate this practice and evaluate in light of new and emerging pests.

In our study, inexpensive cover cropping treatments were planted and evaluated based on natural enemy populations, rates of egg predation, stink bug populations, boll damage, and yield. The direct benefit of integrating cover crops into IPM programs is the potential for boosting biological control, soil quality, and harvestable portions of the grasses, rye, and clover seeds, in addition to reducing the costs of multiple burn-down herbicide applications. This project is part of a broad research initiative to evaluate perennial cover crops that may provide nitrogen during the summer to increase cotton yield and to help stabilize soil structure to prevent erosion.

Objectives

The objective of this study was to evaluate the suitability of different cover crops to reduce pest pressure by increasing biological control. Specific objectives include:

1. Determine effects of cover cropping and border grasses on natural enemy populations.
2. Evaluate the effectiveness of cover cropping for promoting stink bug egg predation.
3. Evaluate the cover-cropping effects on stink bug populations, boll damage, and yield.

Materials and Methods

This study was conducted on a 43,200 square foot field at the University of Georgia's Lang-Rigdon farm located in Tifton, GA. Replicated plots were established using conventional tillage (control) into winter cover crops including crimson clover, white clover, and rye. Crimson clover and rye were terminated prior to cotton planting while the white clover continued to grow as living green mulch throughout the summer. Two grasses, Bermuda and Bahia, were added to determine the effect a border habitat of grasses has on the abundance natural enemies. The six cover treatments were arranged in a Latin square design containing six rows with each treatment replicated once per row. Each individual plot measured 24 feet wide by 40 feet long with 10 feet wide alleys between rows. All plots were prepared by light disking and then establishing the cover crops the previous fall using a cultipacker or grain drill. Cotton (Variety DP 1321 B2RF) was planted in cover treatments using a Unverferth strip till rig that will leave an 8-inch tilled strip to serve as the seed bed, while the conventionally tilled plots were disked followed by a rip and bed pass. The field was irrigated to nurture the cover crops through the winter to establish good growth. Cotton was planted during the first week in May. None of the plots were treated with any insecticides throughout the study.

Insect sampling

Pest populations (aphids, thrips, whiteflies, and stink bugs) were sampled throughout the growing season using sweep net samples. Boll damage was based on assessment of 10 bolls per plot.

Natural enemies were sampled in conjunction with pests. We monitored the ground dwelling natural enemies using pitfall traps and the canopy dwelling predators using beat sheets. A total of four pitfall traps were deployed per sampling date per plot and a total of two beat sheet samples were conducted per plot. Predators collected from canopy samples were immediately transferred to 70% chilled ethanol and stored in a freezer for potential later use in molecular work to assess predation on pests in this system using molecular gut content analysis.

Biological control services- estimating predation and parasitism

Stink bug colonies, housed in the Schmidt lab and Toews' lab at UGA, were used to produce southern green stink bug egg masses. Initially we were hoping to use both species of brown stink bugs and southern green, but were unable to capture enough brown stink bugs to establish a large enough colony. Stink bug egg masses were collected and affixed to four cotton plants per plot in the field plots at two-week intervals during the flowering period. The egg masses were left in the field for a 48-hour period, at which point the eggs were transported to the lab. The number of eggs missing and damaged represented predation. The eggs were incubated to monitor for emergence of parasitoids. All eggs were viewed under a high-powered microscope.

Results and Discussion

Objective 1: Ground dwelling natural enemy populations

To estimate natural enemy movement and the abundance of ground dwelling insects, pitfall traps were administered between the months of April and October 2015. Pitfall traps are used to sample soil active ground predators. Each plot had four pitfall traps that were left out for one week during each of the months sampled. Of the insects captured, over 40,000 of them were ground dwelling natural enemies. These include beneficial insects that live and predate on weed seeds and insect pests found on the ground surrounding cotton. The relative abundance of natural enemies included the following groups: fire ants (18,837), carabid beetles (4,029), spiders (3,939), rove beetles (3,120), earwigs (2,319), and others (Figure 1). The natural enemies represented by "others" include numerous groups of beneficial insects that although were not as abundant as the top five groups listed, were still found in the traps. These natural enemies include other kinds of ground beetles like tiger, scarab, and burrowing beetles as well as some lady beetles, *Geocoris* sp., assassin bugs, crickets, and grass hoppers.

Fire ants dominated the natural enemy communities across all cover treatments, and cover treatments altered the distribution of the natural enemy community ($F_{15, 120} = 1.83$, $P = 0.0381$; Figure 2). The Bermuda and Bahia grass contained the most predators and had a near identical distribution of the top natural enemies. This provides preliminary evidence that the grasses serve as a reservoir for predatory insects and may make an excellent border crop to supply the cotton field with a sufficient amount of natural enemies to keep prey populations low. White clover had a similar distribution of top natural enemies as the grasses, although they did produce fewer predators. This suggests maintaining a clover cover crop in conjunction with a grass border crop helps improve natural enemy populations. The rolled rye and conventional tillage plots did produce the same top predators as the other treatments. However, since the abundance of each group was significantly lower than the clover cover crops and grasses, these would not be considered to best options to promote biological control of cotton pests.

Objective 2: Upper canopy-dwelling natural enemy populations
To estimate natural enemy abundance of upper canopy-dwelling insects, beat sheet samples were conducted between the months of July-October 2015. Teams of 2-3 people would enter each plot and sample it twice by taking nearby cotton plants and shaking it onto a tarp, where each of the insects observed were captured and recorded. Unlike the pitfall traps that remained in the field for one week at a time, beat sheet sampling was done once a month. Approximately 1,800 upper canopy-dwelling natural enemies were collected and identified. These include beneficial insects that live and likely predate on pests found towards the top of the cotton plant. Upper-canopy are likely important to control insect pests. The canopy community of predaceous arthropods consisted of the following groups: spiders (46%), *Geocoris* sp. (26%), fire ants (8%), lady beetles (6%), rove beetles (3%), and others (Figure 3). The natural enemies represented by "others" include numerous groups of beneficial insects that although were not as abundant as the top five groups listed, were still found when the plots were sampled. These natural enemies include numerous true bugs like assassin bugs, damsel bugs, and *Orius* sp. as well as brown and green lacewings. Spiders and *Geocoris* sp. dominated the natural enemy communities across all cover treatments, and cover treatments slightly altered the distribution of the natural enemy community (Figure 4). While all four treatments had the same top predatory insects, conventional tillage, white clover, and rolled rye produced the most predators and had a similar distribution, while crimson clover produced the least amount of natural enemies of the four treatments.

Combining the results of the ground dwelling and upper canopy dwelling natural enemy population data suggests that cover crops greatly affect the abundance and distribution of ground dwelling predators more than upper canopy dwelling natural enemies. Evidence also suggests that white clover has the greatest effect on abundance of ground and upper canopy natural enemies. White clover was the only living mulch that continued to grow during the summer months, which may have contributed to its success for natural enemy recruitment. An additional notable trend is that fire ants, spiders, and rove beetles are prevalent in both the ground and upper canopy of the cotton. This suggests that these insects continue to move up and down the cotton plant in search of prey. Carabid beetles and earwigs were only found on the ground while *Geocoris* and lady beetles were present in only the upper canopy. This suggests that the predators found in both locations may provide biological control services within the plant canopy and on the ground.

Objective 3: Stink bug egg predation
To evaluate the effects of cover cropping on egg predation of the southern green stink bug, *Nezara viridula,* egg masses were deployed into the field once a month between July-October 2015 (Figure 5). A total of over 451 egg masses containing 22,000 eggs were deployed over this period. Egg masses were frozen before being left in the different plots for 48 hours once a month in order to allow time to gather enough egg masses to deploy and eliminate the potential of adding more cotton pests into the field. Egg predation was significantly related to cover crop treatment ($\chi2$ =2595.11, $P<0.0001$) and date deployed to fields ($\chi2$ = 60.1, $P<0.0001$; Figure 5).

Total egg predation across all treatments was 22%, which provides evidence that the natural enemies found in the plots were consuming pests, specifically stink bugs' eggs. Egg predation in the Bermuda (55%) and Bahia (53%) grasses had the highest rates, followed by white clover

(18%), crimson clover (15%), conventional tillage (6%), and rolled rye (4%). Highest level of egg predation occurred in the grasses, which further supports that these grasses are areas where stink bugs are vulnerable to natural enemies. For the cover cropping treatments, clover treatments had the highest rates of egg predation. Specifically, white clover had the highest rate of predation compared to the other treatments and further supports that white clover benefits natural enemy diversity and biocontrol services in cotton.

Objective 3: stink bug populations, boll damage, and yield. Overall, few insect pests were observed in these fields. The levels of thrips, white flies and aphids were nearly undetectable, as we rarely observed these pests over all the plots and over the entire growing season. As for the pest of interest, the southern green stink bug, few were observed over the season for a total of 18 and mean abundance of 4.7 (Figure 6). The current data do suggest that higher numbers of southern green stink bugs correspond with increased boll damage ($F_{1, 113}$=25.73, P<0.0001), and does not appear to be related to cover crop treatments ($F_{3, 113}$ = 0.21, P=0.48; see Figure 7). This could be due to a variety of factors. Stink bugs over all were very low in abundance through the season as noted above. However, they are very elusive and good at hiding in the vegetation, so our estimate is likely conservative for actual populations.

Cotton yields from this study were reported as weights in pounds of seed cotton from 80 linear feet of row. In this first year of the study, we found a significant difference in yield on seed cotton ($F_{3, 20=4.57}$, P=0.01; Figure 8). All treatments showed similar yield, but the living mulch cover, white clover treatment, had significantly lower yield than other cover treatments (Figure 8). We are interested in this finding, as this treatment appeared to show the highest natural enemy populations and corresponding high egg predation on southern green stink bug eggs (Figure 2 and Figure 5). In the field, this result indicates that during the really warm periods lacking rain, water competition between the living mulch and the cotton may have reduced the end season outputs. The result is also suggestive of fine-tuning the irrigation schedule during this period to counteract plant competition. Further research is certainly warranted to understand living mulches and the costs and benefits of integration of this cover-cropping type into the cotton system. The other aspect for further consideration is the significant variation in yield in all plots adjacent to a peanut field, independent of cover treatments. This result suggests that border habitat quality and neighboring systems are important in the whole system management of productive cotton fields.

These data will be combined with similar data to be collected from the same experimental design for 2016 to increase statistical power. Interactive effects will also be examined. These data will be integrated with soil parameters to understand the system changes associated with cover cropping. We expect that the effects of cover cropping change as a system becomes established and soil properties change in response to nutrients and soil texture. The long-term hope is to scale this experiment up to look further at the effects on erosion, nitrogen, weed control, and pest management at much larger spatial scales.

These results are important since the integration of living or dead mulches coupled with reduced tillage may allow growers to utilize fewer pesticide applications to manage pests, and economic returns while increasing other ecosystem services (such as soil health and erosion prevention). Results suggest that providing forage grass border habitats and planting cover crops have positive effects on natural enemy populations and may contribute to long-term ecologically friendly management of pest populations in cotton agroecosystems.

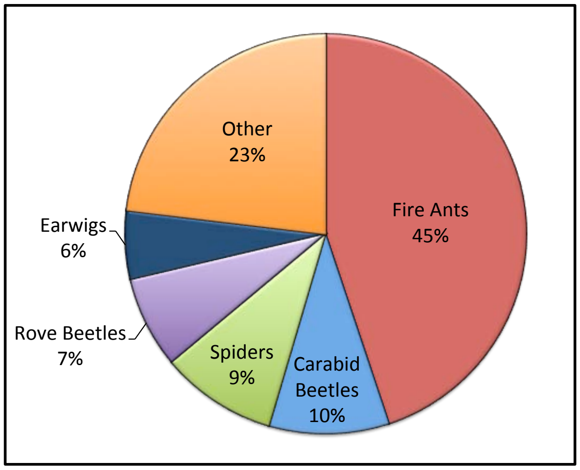

Figure 1: Percent abundance of ground-dwelling predators across all treatments.

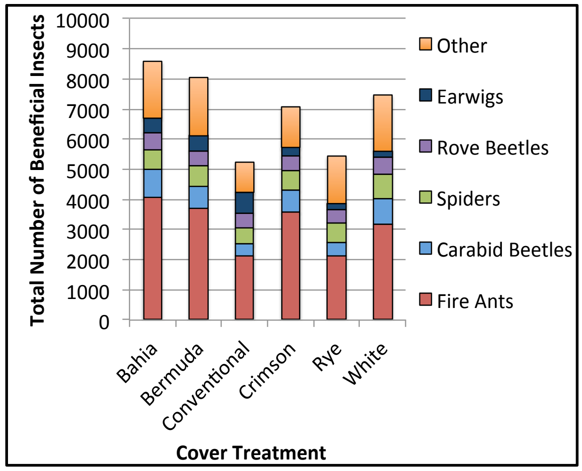

Figure 2: Ground-dwelling predator abundance by individual treatment.

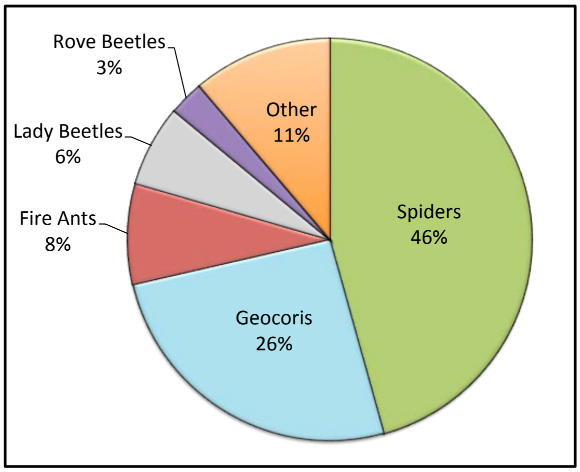

Figure 3: Percent abundance of canopy-dwelling predators across all treatments.

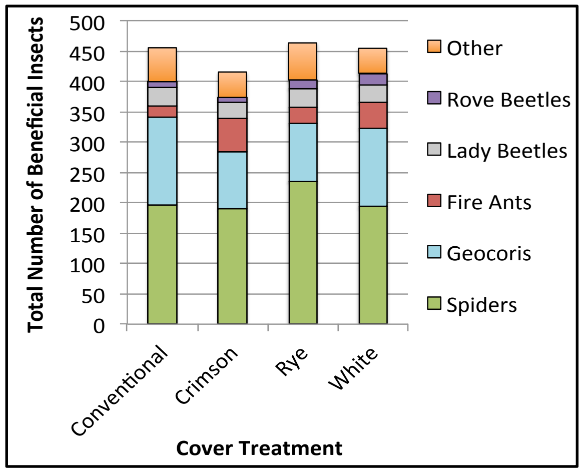

Figure 4: Canopy-dwelling predator abundance by individual treatment.

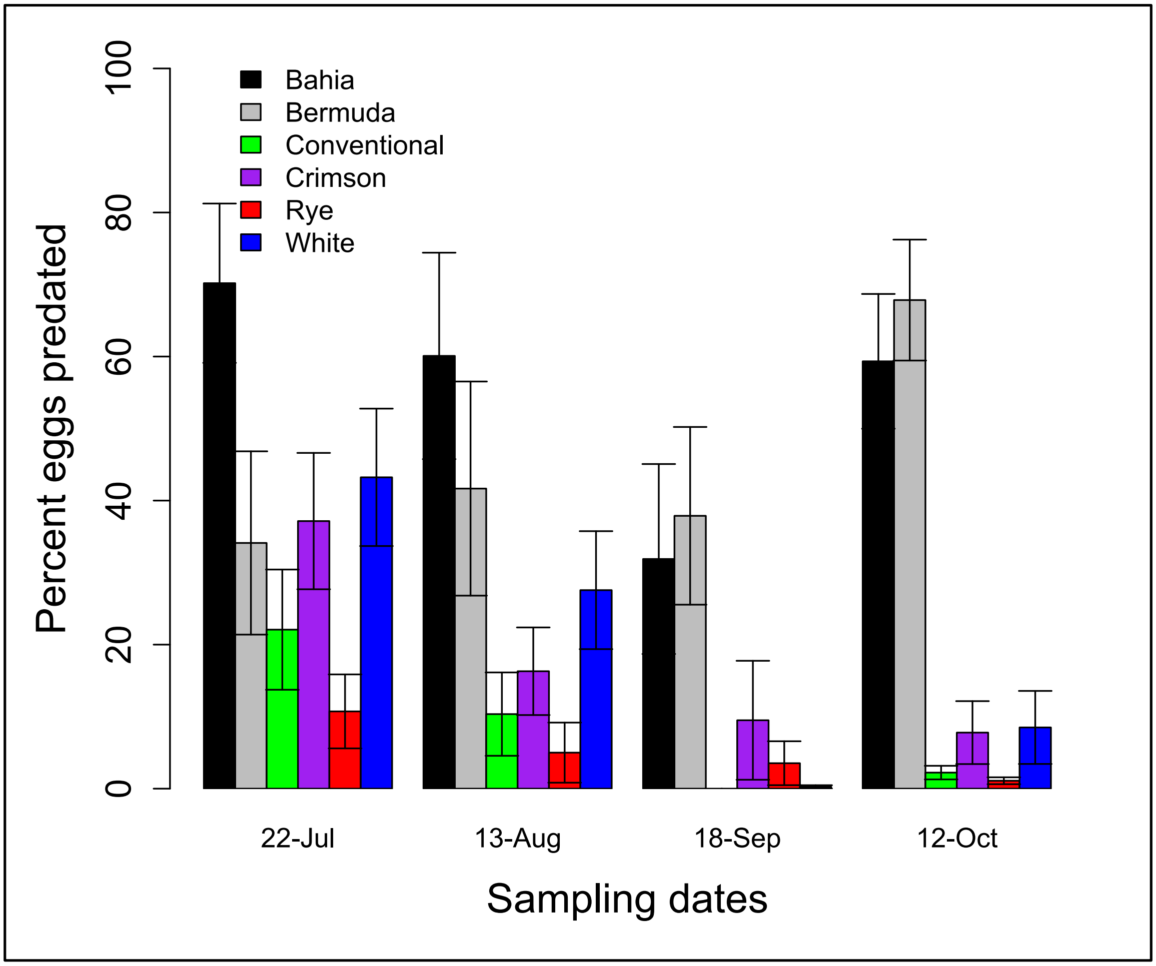

Figure 5: The percent of stink bug eggs natural enemies predated on per individual treatment on four sampled dates. Provides evidence that cover crop as well as other factors affect the rate of predation.

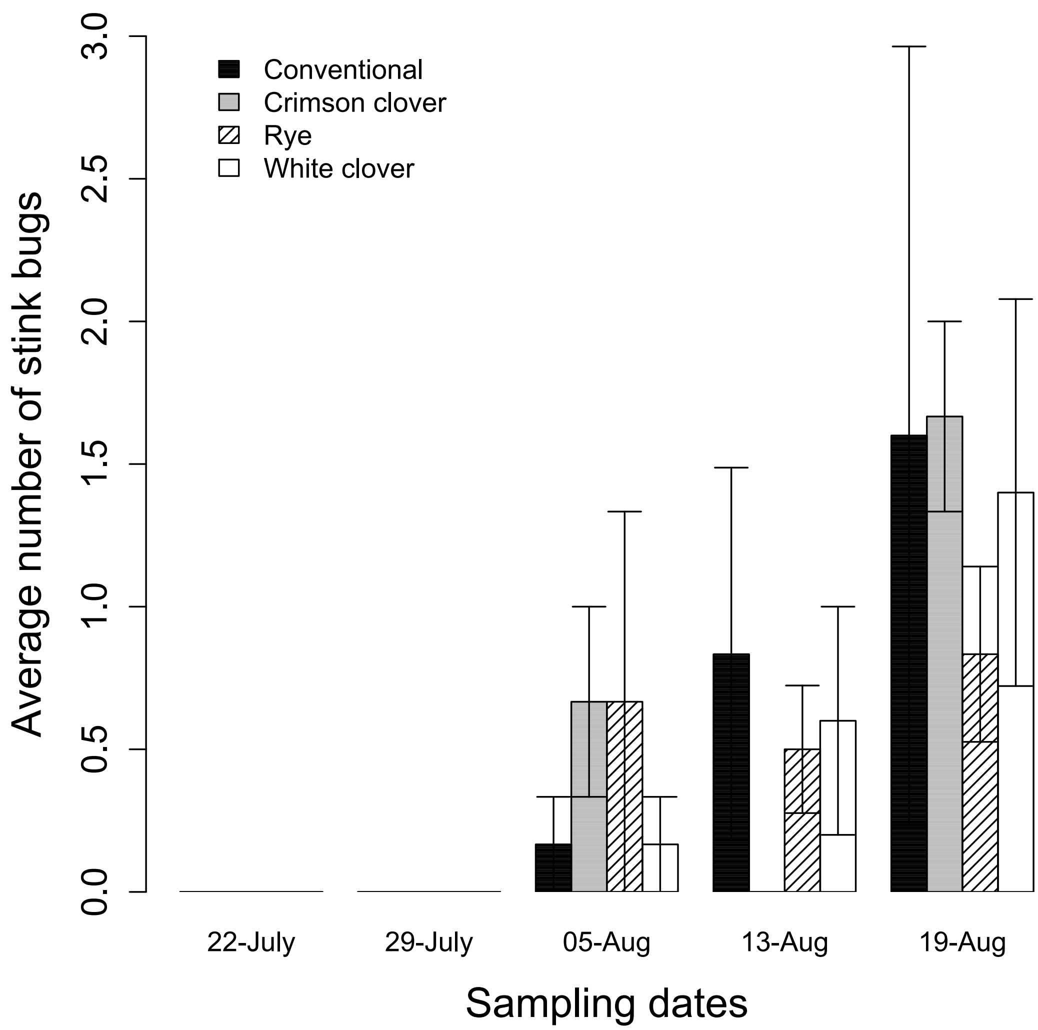

Figure 6. Average of the number of stink bugs observed in plots in relation to cover crop treatments and date sampled.

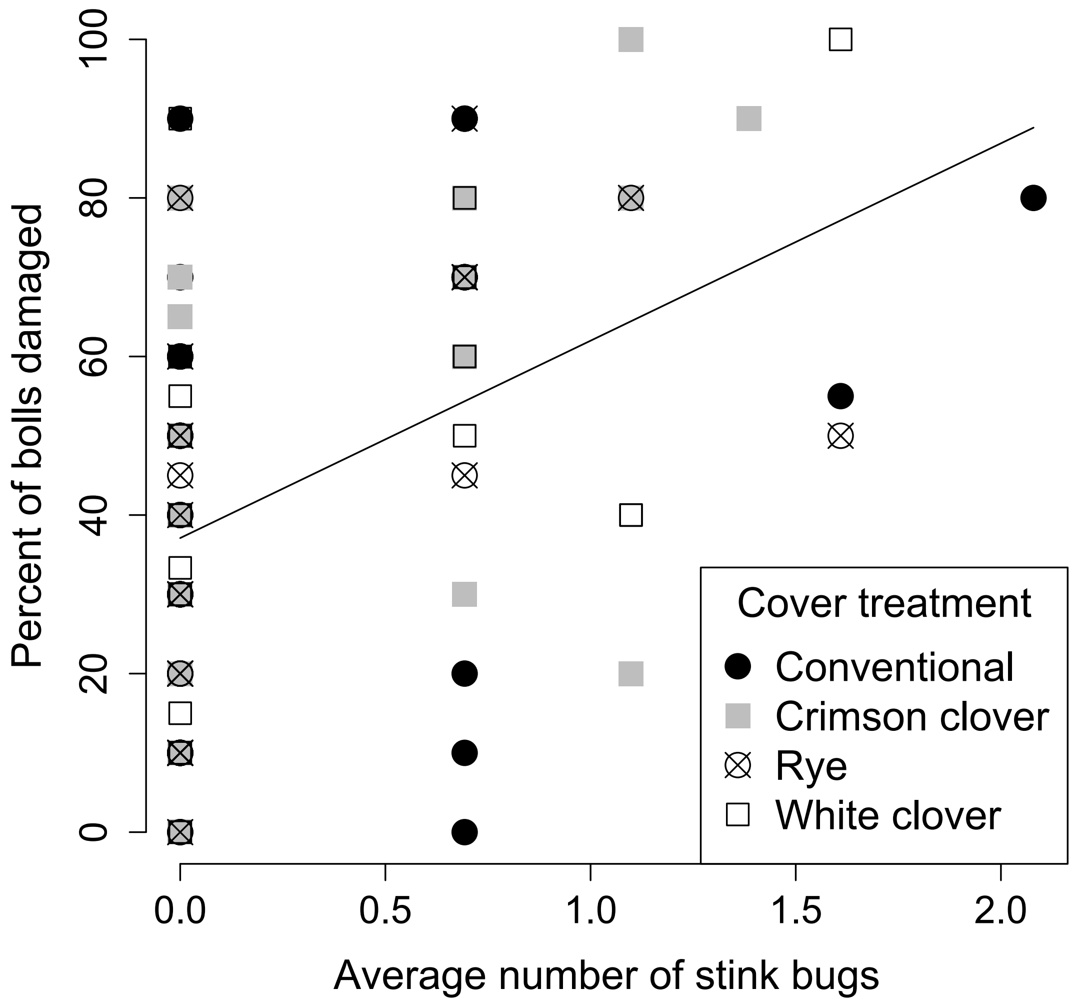

Figure 7. Scatterplot showing the data relating number of stink bugs observed in experimental plots and percent of bolls damaged by stink bugs. Cover crop treatments are indicated in this scatterplot by symbols. The line represents the positive correlation.

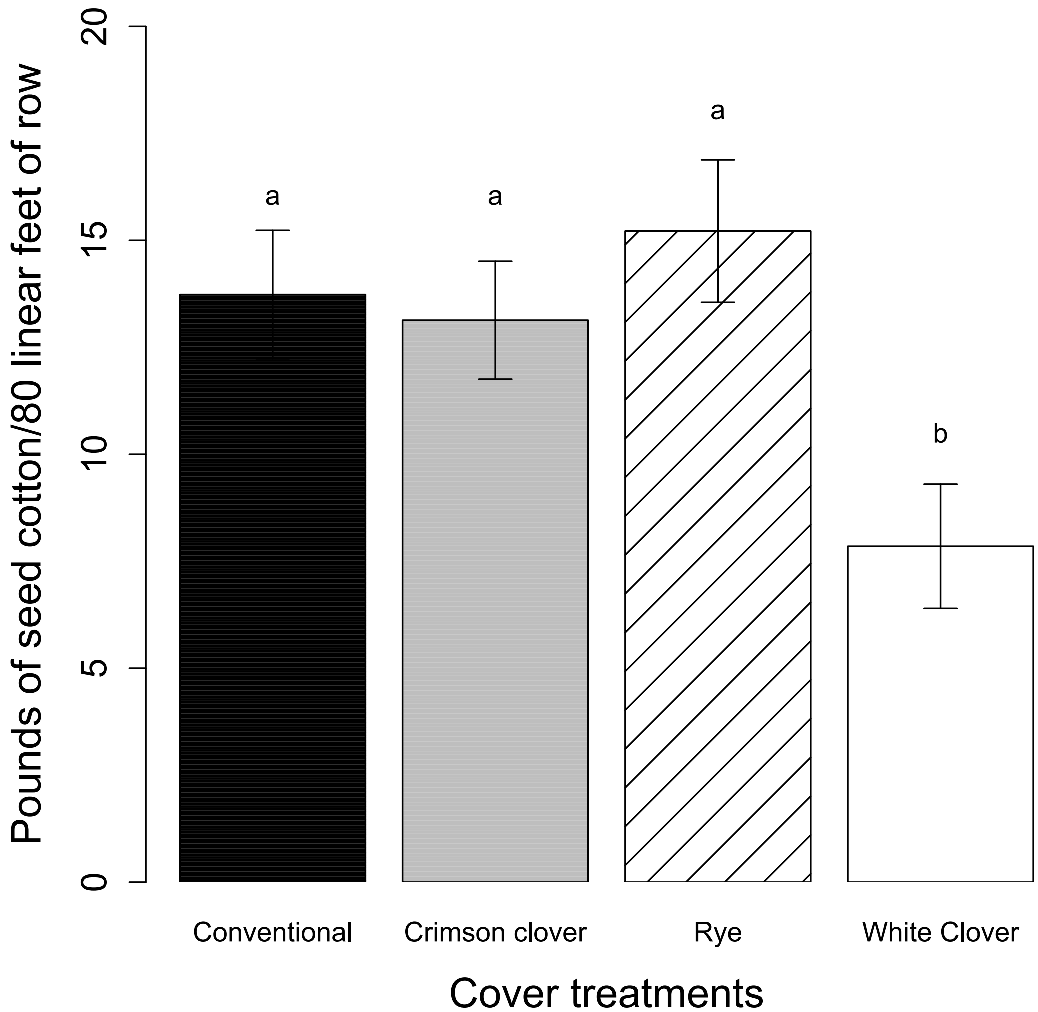

Figure 8. Summary of the effects of cover cropping on pounds of seed cotton. The center rows of the treatments were harvested to reduce any edge effects.

Acknowledgements

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Literature Cited

Bond, W., & Grundy, A. C. 2001. Non-chemical weed management in organic farming systems. Weed research, *41*(5), 383-405.

Tillman, G., Schomberg, H., Phatak, S., Mullinix, B., Lachnicht, S., Timper, P., & Olson, D. 2004. Influence of cover crops on insect pests and predators in conservation tillage cotton. Journal of Economic Entomology, *97(4),* 1217-1232.

ALTERNATIVE OR SUPPLEMENTARY INSECTICIDE MANAGEMENT OF SHORT-HORNED GRASSHOPPERS, THRIPS, AND OTHER EARLY SEASON PESTS IN CONSERVATION TILLAGE COTTON IN SINGLE AND TWIN ROWS

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Introduction

The research objective was to develop information on cost effective management of short-horned grasshoppers, thrips, and other early season pests in conservation tillage cotton using replicated field experiments at the UGA Southeastern Branch Research and Education Center near Midville. The goal was to evaluate various cultural procedures and insecticide options for controlling short-horned grasshoppers, thrips, and other early season pests. Chemical pest management programs were evaluated in agricultural regimes of single row and twin row cotton in either conservation tillage or plow tillage environments.

Procedures

A 5-acre field was planted in rye in the fall of 2014. On May 21, a randomized split block experiment was established in the test field with seedbed preparation of strip tillage blocks having rye cover killed with Roundup 7 days before planting. Plow tillage blocks were cultivated 7 days before and at planting. When cotton reached four leaves (26 days after planting), the plots were sprayed with Roundup for weed management. Each 8 row plot was separated and 4 rows were sprayed with Orthene (1.0 lb a.i./ac). Single row and twin row planting procedures used the same seeding rate and used either a single seedbed at 36 inch row width or twin rows which were approximately 8 inches wide with 36 inches separating the middle of each twin row.

At-planting insecticide seed treatments were either neonicotinoid (Cruiser @ 0.25 mg a.i./seed) or Orthene (@ 1.0 lb a.i./ac). In-furrow treatment with Thimet (at 0.35 lb a.i./ac) was also evaluated. Thimet was applied in the seed furrow using conventional granular applicators mounted on each planter. Single and twin row cotton was used with the insecticide treatments both in conservation tillage and plow tillage blocks.

The tests were sampled for thrips 14 and 35 days after planting and the fields were monitored for short-horned grasshopper infestations weekly for the first 30 days after seedling emergence and then every other week by walking 2x4 ft wide transits across the field while counting all short-horned grasshoppers. Thrips were collected from 10 plants/plot and the samples were returned to the laboratory for counting and insect identification. Visual estimate of percent thrips-infested plants and percent stand vigor were made in each plot 14 and 35 days after planting. Yields were taken at the end of the season by harvesting and weighing the cotton in the two middle rows of each plot with a cotton picker.

Results and Discussion

The stand of rye planted in the fall of 2014 germinated poorly and grew sparsely during winter, and light cover was present in May for the 2015 cotton test. Short-horned grasshopper populations were low during the season and produced little damage to the seedling cotton. This was likely related to the wetter than usual weather that occurred during much of the 2015 season. Short-horned grasshoppers are generally considered to produce the greatest damage in hot, dry conditions. However, the numbers of short-horned grasshopper adults and nymphs were consistently greater in conservation tillage plots compared to plow tillage from planting time and throughout the season (average of 0.342 hoppers/plot in conservation tillage compared to 0.075 in plow tillage throughout the season). Sampling data indicated that none of the planting time insecticide treatments affects grasshoppers on seedling cotton until Orthene was applied 26 days after planting. Grasshopper numbers were reduced by half or more in the treatments receiving the Orthene sprays at 26 days. The 2015 results with the low populations of short-horned grasshoppers confirm previous years' findings in tests where higher numbers of insects were present. These findings are that (1) higher grasshopper populations occur in reduced tillage conditions compared to plow tillage, (2) grasshopper numbers were similar in single row vs. twin row cotton, (3) conventional planting-time insecticide treatments have little or no effect on control of short-horned grasshopper infestations on seedling cotton, and (4) a supplemental insecticide treatment with Orthene at 1 lb a.i./ac in the 4-leaf stage is effective in reducing numbers of grasshopper nymphs and adults.

Table 1 shows results from sampling thrips (these were mostly tobacco thrips, adults and immatures) on the cotton foliage at 14 and 33 (7 days following spaying Orthene at 1.0 a.i./ac in half of the plots) days after planting. Overall, there was no significant difference in thrips numbers between conservation tillage and plow tillage, or single row vs. twin row cultural systems. In the past, thrips numbers have generally been reduced in conservation systems in experiments designed to compare reduced tillage and plow tillage. In 2015 the surface debris in conservation tillage blocks was greatly reduced compared to previous years. Observations indicate that when there are high levels of small grain debris in conservation tillage plots, thrips numbers are usually lowest when compared to similar plow tillage treatments where no surface debris is present. Comparing twin row and single row cotton, there were no significant differences in thrips numbers irrespective of tillage practice or insecticides. This indicates that twin row planting practice does not influence thrips risk on seedling cotton either positively or negatively.

Thimet had the highest control of thrips at 14 DAP (days after planting) on seedling cotton in either tillage system. Numbers were similar in single row and twin row planting. Granules were applied at half the rate in each row of a twin row plot, and the results indicate that thrips control on individual plants was similar to the single row cotton which had 1 lb a.i./ac applied in-furrow. This may indicate that there is a crossover of Thimet residues in the 8 inches separating rows. Estimates of % thrips damage were usually lowest and % crop vigor highest in the Thimet treatments in the two different tillages and planting procedures. The 26 day spray with Orthene at 1 lb a.i./ac did not have significant impact on the low numbers of insects present in the Thimet treatments.

Cruiser seed treatment (0.25 mg a.i./seed) reduced thrips populations on cotton seedlings at 14 DAP compared to Orthene at 1 lb a.i./seed in conservation tillage and plow tillage with single or twin row. When Orthene at 1.lb a.i./ac was applied to half the plots 26 days after planting with the Cruiser and Orthene treatments, the thrips numbers were significantly reduced compared to the plots that did not receive the sprays.

The yields of the various treatments were not statistically different at P=0.05, but trends were apparent. In comparing treatments where the only variable was single row or double row, single row cotton had consistently higher yield. These results are similar to previous testing that focused on the agronomics of the two planting procedures that showed that there was little yield advantage of twin rows over single rows in cotton. Yield was highest in plow tillage cotton treated with Thimet at planting time, which received supplemental Orthene sprays over plots at

26 days after planting. Similar trends were also observed with the two seed treatments with highest yields in plow tillage plots that had been treated with Orthene at the time that Roundup was applied for weed management. Overall, test results indicate that there is insect management and yield advantage to using insecticide sprays on cotton seedlings at about 4 weeks after planting as a supplement to using planting time insecticides.

Table 1. Insect infestation parameters and yield in the 2015 field experiment at the University of Georgia Southeastern Branch Research and Education Center.

NT=no-tillage, PT=plow tillage, SR=single row, TR=twin row, DAP=days after planting, IF=in furrow, ST=seed treatment

Till-age	Row	Chem IF or ST	Orth-ene spray	Thrips 6/4	% thrips damage 6/9	% vigor 6/9	% thrips damage 6/23	% vigor 6/23	Thrips 6/23	Grass-hopper total	Thrips total	Yield 9/16
DAP			26	14	19	19	33	33	33			179
NT	SR	Cruiser	O				15.0 a	87.5 a	1.3 bc	0.3 a	23.0 fgh	3607 a
NT	SR	Cruiser		21.8 bc	10.0 abc	85.0 a	35.0 a	72.5 a	9.8 ab	0.5 a	31.5 e-h	3349 a
NT	TR	Cruiser	O				30.0 a	78.8 a	1.0 bc	0.0 a	26.3 fgh	3349 a
NT	TR	Cruiser		25.3 bc	8.8 bc	83.8 a	33.8 a	76.3 a	8.0 abc	0.0 a	33.3 d-h	3076 a
NT	SR	Orthene	O				37.5 a	78.8 a	2.0 bc	0.3 a	66.8 a-e	3489 a
NT	SR	Orthene		64.8 a	17.0 ab	85.0 a	21.3 a	82.5 a	4.5 abc	0.5 a	69.3 a-d	3371 a
NT	TR	Orthene	O				41.3 a	73.8 a	0.3 bc	0.3 a	43.3 b-g	3390 a
NT	TR	Orthene		43.0ab	22.5 a	85.0 a	20.0 a	82.5 a	4.5 abc	0.3 a	47.5 b-f	3172 a
NT	SR	Thimet	O				32.5 a	78.8 a	1.0 bc	0.5 a	6.3 h	3698 a
NT	SR	Thimet		5.3 c	5.0 bc	96.3 a	11.3 a	92.5 a	2.0 bc	1.0 a	7.3 gh	3694 a
NT	TR	Thimet	O				17.5 a	83.8 a	1.3 bc	0.3 a	9.5 gh	3358 a
NT	TR	Thimet		8.3 c	8.8 bc	91.3 a	7.5 a	88.8 a	3.0 abc	0.0 a	11.3 fgh	3149 a
PT	SR	Cruiser	O				35.0 a	85.0 a	3.5 abc	0.0 a	14.5 fgh	3576 a
PT	SR	Cruiser		11.0 bc	2.5 c	95.0 a	35.0 a	88.8 a	9.8 ab	0.0a	20.8 fgh	3594 a
PT	TR	Cruiser	O				16.3 a	91.3 a	1.3 bc	0.3 a	28.8 fgh	3562 a
PT	TR	Cruiser		27.5 bc	13.8 abc	87.5 a	32.5 a	85.0 a	9.8 ab	0.3 a	37.3 c-h	3498 a
PT	SR	Orthene	O				16.3 a	93.8 a	2.3 abc	0.0 a	72.8 abc	3766 a
PT	SR	Orthene		70.5 a	11.3 abc	87.5 a	33.8 a	82.5 a	8.5 abc	0.0 a	79.0 ab	3766 a
PT	TR	Orthene	O				31.3 a	81.3 a	1.3 bc	0.3 a	75.0 ab	3498 a
PT	TR	Orthene		73.8 a	11.3 abc	91.3 a	23.8 a	88.8 a	11.8 a	0.0 a	85.5 a	3430 a
PT	SR	Thimet	O				8.8 a	96.3 a	0.0 c	0.0 a	4.8 h	3807 a
PT	SR	Thimet		4.8 c	6.3 bc	96.3 a	17.5 a	93.8 a	1.3 bc	0.0 a	6.0 h	3630 a
PT	TR	Thimet	O				11.3 a	92.5 a	1.5 bc	0.0 a	5.5 h	3553 a
PT	TR	Thimet		4.0 c	12.5 abc	85.0 a	15.0 a	85.0 a	3.3 abc	0.0 a	7.3 gh	3194 a

Table 2. Comparison of insect control in the three planting time insecticide treatments used in the test in single row no-tillage treatments.

	Thrips 6/4	% thrips damage 6/9	% vigor 6/9	% thrips damage 6/23	% vigor 6/23	Thrips 6/23	Grass-hoppers total	Thrips total	Yield lb/ac 9/16
Thimet	5.3b	5a	96.3a	11.3a	92.5a	2a	1a	7.3b	3694a
Cruiser ST	21.8ab	10a	85b	35a	72.5a	9.8a	0.5a	31.5ab	3349a
Orthene ST	64.8a	17a	85b	21.3a	82.5a	4.5a	0.5a	69.3a	3371a

Table 3. Comparison of insect control in the three planting time insecticide treatments used in the test in twin row no-tillage treatments.

	Thrips 6/4	% thrips damage 6/9	% vigor 6/9	% thrips damage 6/23	% vigor 6/23	Thrips 6/23	Grass-hoppers total	Thrips total	Yield lb/ac 9/16
Thimet	8.3b	8.8b	91.3a	7.5a	88.8a	3a	0a	11.3b	3149a
Cruiser ST	25.3ab	8.8b	83.8a	33.8a	76.3a	8a	0a	33.3a	3076a
Orthene ST	43a	22.5a	85a	20a	82.5a	4.5a	0.3a	47.5a	3172a

Table 4. Comparison of insect control in the three planting time insecticide treatments used in the test in single row plow tillage treatments.

	Thrips 6/4	% thrips damage 6/9	% vigor 6/9	% thrips damage 6/23	% vigor 6/23	Thrips 6/23	Grass-hoppers total	Thrips total	Yield lb/ac 9/16
Thimet	4.8b	6.3ab	96.3a	17.5a	93.8a	1.3b	0a	6b	3630a
Cruiser ST	11b	2.5b	95a	35a	88.8a	9.8a	0a	20.8b	3594a
Orthene ST	70.5a	11.3a	87.5a	33.8a	82.5a	8.5ab	0a	79a	3766a

Table 5. Comparison of insect control in the three planting time insecticide treatments used in the test in twin row plow tillage treatments.

	Thrips 6/4	% thrips damage 6/9	% vigor 6/9	% thrips damage 6/23	% vigor 6/23	Thrips 6/23	Grass-hoppers total	Thrips total	Yield lb/ac 9/16
Thimet	4b	12.5a	85a	15a	85a	3.3a	0a	7.3c	3194a
Cruiser ST	27.5b	13.8a	87.5a	32.5a	85a	9.8a	0.3a	37.3b	3498a
Orthene ST	73.8a	11.3a	91.3a	23.8a	88.8a	11.8a	0a	85.5a	3430a

Table 6. Comparison of insect control in the three planting time insecticide treatments used in the test in single row no-tillage and plow tillage treatments combined.

Till-age	Row	Chem IF or ST	Orth-ene spray	Thrips 6/4	% thrips damage 6/9	% vigor 6/9	% thrips damage 6/23	% vigor 6/23	Thrips 6/23	Grass-hopper total	Thrips total	Yield 9/16
DAP			26	14	19	19	33	33	33			179
NT	SR	Cruiser	O				15.0 a	87.5 a	1.3 bc	0.3 a	23.0 c	3607 a
NT	SR	Cruiser		21.8 b	10.0 a	85.0 b	35.0 a	72.5 a	9.8 a	0.5 a	31.5 bc	3349 a
NT	SR	Orthene	O				37.5 a	78.8 a	2.0 bc	0.3 a	66.8 ab	3489 a
NT	SR	Orthene		64.8 a	17.0 a	85.0 b	21.3 a	82.5 a	4.5 abc	0.5 a	69.3 ab	3371 a
NT	SR	Thimet	O				32.5 a	78.8 a	1.0 bc	0.5 a	6.3 c	3698 a
NT	SR	Thimet		5.3 b	5.0 a	96.3 a	11.3 a	92.5 a	2.0 bc	1.0 a	7.3 c	3694 a
PT	SR	Cruiser	O				35.0 a	85.0 a	3.5 abc	0.0 a	14.5 c	3576 a
PT	SR	Cruiser		11.0 b	2.5 a	95.0 ab	35.0 a	88.8 a	9.8 a	0.0a	20.8 c	3594 a
PT	SR	Orthene	O				16.3 a	93.8 a	2.3 abc	0.0 a	72.8 a	3766 a
PT	SR	Orthene		70.5 a	11.3 a	87.5 ab	33.8 a	82.5 a	8.5 ab	0.0 a	79.0 a	3766 a
PT	SR	Thimet	O				8.8 a	96.3 a	0.0 c	0.0 a	4.8 c	3807 a
PT	SR	Thimet		4.8 b	6.3 a	96.3 a	17.5 a	93.8 a	1.3 bc	0.0 a	6.0 c	3630 a

Table 7. Comparison of insect control in the three planting time insecticide treatments used in the test in twin row no-tillage and plow tillage treatments combined.

Till-age	Row	Chem IF or ST	Orth-ene spray	Thrips 6/4	% thrips damage 6/9	% vigor 6/9	% thrips damage 6/23	% vigor 6/23	Thrips 6/23	Grass-hopper total	Thrips total	Yield 9/16
DAP			26	14	19	19	33	33	33			179
NT	TR	Cruiser	O				30.0 a	78.8 a	1.0 b	0.0 a	26.3 b-e	3349 a
NT	TR	Cruiser		25.3 bc	8.8 b	83.8 a	33.8 a	76.3 a	8.0 ab	0.0 a	33.3 bcd	3076 a
NT	TR	Orthene	O				41.3 a	73.8 a	0.3 b	0.3 a	43.3 b	3390 a
NT	TR	Orthene		43.0 b	22.5 a	85.0 a	20.0 a	82.5 a	4.5 ab	0.3 a	47.5 b	3172 a
NT	TR	Thimet	O				17.5 a	83.8 a	1.3 ab	0.3 a	9.5 de	3358 a
NT	TR	Thimet		8.3 c	8.8 b	91.3 a	7.5 a	88.8 a	3.0 ab	0.0 a	11.3 cde	3149 a
PT	TR	Cruiser	O				16.3 a	91.3 a	1.3 ab	0.3 a	28.8 b-e	3562 a
PT	TR	Cruiser		27.5 bc	13.8 ab	87.5 a	32.5 a	85.0 a	9.8 ab	0.3 a	37.3 bc	3498 a
PT	TR	Orthene	O				31.3 a	81.3 a	1.3 ab	0.3 a	75.0 a	3498 a
PT	TR	Orthene		73.8 a	11.3 b	91.3 a	23.8 a	88.8 a	11.8 a	0.0 a	85.5 a	3430 a
PT	TR	Thimet	O				11.3 a	92.5 a	1.5 ab	0.0 a	5.5 e	3553 a
PT	TR	Thimet		4.0 c	12.5 ab	85.0 a	15.0 a	85.0 a	3.3 ab	0.0 a	7.3 de	3194 a

Table 8. Comparison of insect control in all Cruiser treatments used in no-tillage, plow tillage, twin row and single row.

Till-age	Row	Chem IF or ST	Orth-ene spray	Thrips 6/4	% thrips damage 6/9	% vigor 6/9	% thrips damage 6/23	% vigor 6/23	Thrips 6/23	Grass-hopper total	Thrips total	Yield 9/16
DAP			26	14	19	19	33	33	33			179
NT	SR	Cruiser	O				15.0 a	87.5 a	1.3 a	0.3 a	23.0 a	3607 a
NT	SR	Cruiser		21.8 a	10.0 ab	85.0 a	35.0 a	72.5 a	9.8 a	0.5 a	31.5 a	3349 a
NT	TR	Cruiser	O				30.0 a	78.8 a	1.0 a	0.0 a	26.3 a	3349 a
NT	TR	Cruiser		25.3 a	8.8 ab	83.8 a	33.8 a	76.3 a	8.0 a	0.0 a	33.3 a	3076 a
PT	SR	Cruiser	O				35.0 a	85.0 a	3.5 a	0.0 a	14.5 a	3576 a
PT	SR	Cruiser		11.0 a	2.5 b	95.0 a	35.0 a	88.8 a	9.8 a	0.0a	20.8 a	3594 a
PT	TR	Cruiser	O				16.3 a	91.3 a	1.3 a	0.3 a	28.8 a	3562 a
PT	TR	Cruiser		27.5 a	13.8 a	87.5 a	32.5 a	85.0 a	9.8 a	0.3 a	37.3 a	3498 a

Table 9. Comparison of insect control in all Cruiser treatments used in no-tillage, plow tillage, twin row and single row.

Till-age	Row	Chem IF or ST	Orth-ene spray	Thrips 6/4	% thrips damage 6/9	% vigor 6/9	% thrips damage 6/23	% vigor 6/23	Thrips 6/23	Grass-hopper total	Thrips total	Yield 9/16
DAP			26	14	19	19	33	33	33			179
NT	SR	Orthene	O				37.5 a	78.8 a	2.0 a	0.3 a	66.8 a	3489 a
NT	SR	Orthene		64.8 a	17.0 a	85.0 a	21.3 a	82.5 a	4.5 a	0.5 a	69.3 a	3371 a
NT	TR	Orthene	O				41.3 a	73.8 a	0.3 a	0.3 a	43.3 a	3390 a
NT	TR	Orthene		43.0a	22.5 a	85.0 a	20.0 a	82.5 a	4.5 a	0.3 a	47.5 a	3172 a
PT	SR	Orthene	O				16.3 a	93.8 a	2.3 a	0.0 a	72.8 a	3766 a
PT	SR	Orthene		70.5 a	11.3 a	87.5 a	33.8 a	82.5 a	8.5 a	0.0 a	79.0 a	3766 a
PT	TR	Orthene	O				31.3 a	81.3 a	1.3 a	0.3 a	75.0 a	3498 a
PT	TR	Orthene		73.8 a	11.3 a	91.3 a	23.8 a	88.8 a	11.8 a	0.0 a	85.5 a	3430 a

Table 10. Comparison of insect control in all Thimet treatments used in no-tillage, plow tillage, twin row and single row.

Till-age	Row	Chem IF or ST	Orth-ene spray	Thrips 6/4	% thrips damage 6/9	% vigor 6/9	% thrips damage 6/23	% vigor 6/23	Thrips 6/23	Grass-hopper total	Thrips total	Yield 9/16
DAP			26	14	19	19	33	33	33			179
NT	SR	Thimet	O				32.5 a	78.8 a	1.0 a	0.5 a	6.3 a	3698 a
NT	SR	Thimet		5.3 a	5.0 a	96.3 a	11.3 a	92.5 a	2.0 a	1.0 a	7.3 a	3694 a
NT	TR	Thimet	O				17.5 a	83.8 a	1.3 a	0.3 a	9.5 a	3358 a
NT	TR	Thimet		8.3 a	8.8 a	91.3 a	7.5 a	88.8 a	3.0 a	0.0 a	11.3 a	3149 a
PT	SR	Thimet	O				8.8 a	96.3 a	0.0 a	0.0 a	4.8 a	3807 a
PT	SR	Thimet		4.8 a	6.3 a	96.3 a	17.5 a	93.8 a	1.3 a	0.0 a	6.0 a	3630 a
PT	TR	Thimet	O				11.3 a	92.5 a	1.5 a	0.0 a	5.5 a	3553 a
PT	TR	Thimet		4.0 a	12.5 a	85.0 a	15.0 a	85.0 a	3.3 a	0.0 a	7.3 a	3194 a

Treatments are compared statistically by column. ANOVA, Tukey HSD P = 0.05

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