CULTIVAR EVALUATION: EVOLUTION OF SYSTEMS TRIALS TO COMPARE TRANSGENIC AND NON-TRANSGENIC CULTIVARS

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Abstract

Systems trials allow cultivar performance and economic returns to be compared when cultivars are produced according to the pest management program appropriate for the cultivar type, while Official Cultivar Trials (OCTs) impose common management on all cultivars. Thus, the OCT protocol for testing cultivars may be inadequate as the sole source of performance data for transgenic cultivars containing pest management traits. The objective of this trial is to compare net economic returns from producing non-transgenic and transgenic pest managing cultivars in their intended production system. Sixteen cultivars, four each representing non-transgenic, Roundup Ready®, Bollgard®, and stacked (Roundup Ready+Bollgard) cultivars, were planted on 10 May in a randomized complete block design with four replications. Plot size was 6-rows, 36-inch row spacing, 50 feet long. Cultivars in the trial included Deltapine DeltaPearl, FiberMax® 989, Phytogen GA161, Stoneville 580, Deltapine 5415R, FiberMax 989R, Stoneville 4793R, SureGrow 521R, Deltapine 448B, Deltapine Nucotn 33B, FiberMax 966B, Stoneville 4691B, Deltapine 555BR, Deltapine 458BR, FiberMax 989BR, and Stoneville 4892BR. Cultivars chosen for inclusion in the trial presently have large seed market share in Georgia, proven performance in the University of Georgia Official Cultivar Trials (www.griffin.peachnet.edu/cotton/), or have promise as new cultivars for Georgia growers (and are projected to be commercially available within 1-2 years). The cultivars Stoneville 4691B, Stoneville 4892BR, FiberMax 966B, Deltapine 555BR, FiberMax 989, Deltapine Nucotn 33B, and Deltapine 458BR were the highest yielders in the trial (statistically speaking), while Deltapine 555BR had the highest gin turnout. Insect densities were unusually low in 2001 at the Tifton, GA trial site. Densities of lepidopteran pest insects never triggered an insecticide application for their control on either Bollgard or non-Bollgard cultivars, thus we could not effectively compare insect control costs under more normal pest insect pressure between Bollgard and non-Bollgard insect management systems. Weed management was excellent with either the Roundup Ready or non-Roundup Ready herbicide regimes. Yellow nutsedge (*Cyperus esculentus* L.) and smallflower morningglory (*Jacquemontia tamnifolia* L.) were observed sporadically in the trial prior to applications of herbicides. Thereafter, densities of weed species remained low. Net returns averaged $536.43/acre for Roundup Ready cultivars, while stacked (Bollgard + Roundup Ready) cultivars returned an average of $584.76/acre. Low densities of insect and weed pests prohibited us from separating cultivars and types (e.g., transgenic or not) on the basis of efficacy of pest management. Net returns from this trial appear to be more influenced by yield potential of the background genotype than by presence or absence of genes conferring pest management traits. As of this writing, HVI fiber data was not yet available, thus discounts or premiums imposed by the marketing system could not be factored into net returns for each cultivar. Based on HVI fiber data collected in the University of Georgia Official Cultivar Trials, we expect cultivar variation in fiber properties and perhaps color/trash grades to slightly alter net returns for cultivars we studied. In summary, stacked (Bollgard plus Roundup Ready) cultivars produced the highest returns. In the absence of more normal insect and weed pest populations, net returns in this trial were more related to yield potential of the background genotype than to presence of transgenically mediated, pest management, traits. Results of 'systems' trials combined with data from state OCTs should assist producers in choosing cultivars and production systems to better optimize profits.

Introduction

About 78% of the 2001 U.S. cotton hectarage (USDA-AMS, 2001) was planted to transgenic cultivars containing genes conferring glyphosate (Roundup Ready) herbicide tolerance, Bollgard mediated lepidopteran insect management, or both (Roundup Ready+Bollgard), plus smaller hectarage planted to bromoxynil (BXN®) herbicide resistant cultivars. Despite the dominance of transgenic cultivars in U.S. production, OCTs remain the primary vehicles for testing cultivars. The presence of transgenic, pest-managing and non-transgenic cultivars in OCTs poses challenges to provide unbiased cultivar performance because OCTs typically impose pest management regimes appropriate for non-transgenic cultivars. Transgenic technology developers, growers, and some scientists have called for OCT test protocols to evolve in tandem with transgenic technology, while also questioning the applicability of OCT performance data. The high level of lepidopterous insect control conferred by the Bollgard technology (Jenkins et al., 1997), plus the capability of herbicide tolerant cultivars to be produced with fewer soil-applied herbicides and potential reduction in their yield drag effects (Culpepper et al., 2002; May and Murdock, 2002) has led the Cotton Seed industry, transgenic technology providers, and even producers to question the validity of testing transgenic cultivars in OCTs and fairly comparing them with non-transgenic cultivars.

An alternative for testing cultivars is to augment OCTs with systems trials wherein the best performing transgenic and non-transgenic cultivars in OCTs are produced with their respective pest management programs. The objective of this study is to compare cultivar performance and net economic returns from producing non-transgenic and transgenic, pest managing cultivars in their intended production system. These data and that from state Official Cultivar Trials should assist producers in choosing cultivars and production systems to maximize profits.

Materials and Methods

Sixteen cultivars, four each representing non-transgenic, Roundup Ready, Bollgard, and stacked (Roundup Ready+Bollgard) cultivars, were planted on 10 May in a randomized complete block design with four replications. Plot size was 6-rows, 36-inch row spacing, 50 feet long. Cultivars in the trial included Deltapine DeltaPearl, FiberMax 989, Phytogen GA161, Stoneville 580, Deltapine 5415R, FiberMax 989R, Stoneville 4793R, SureGrow 521R, Deltapine 448B, Deltapine Nucotn 33B, FiberMax 966B, Stoneville 4691B, Deltapine 555BR, Deltapine 458BR, FiberMax 989BR, and Stoneville 4892BR (Table 1). Cultivars chosen for inclusion in the trial presently have large seed market share in Georgia (USDA-AMS, 2001), proven performance in the University of Georgia OCTs (www.griffin.peachnet.edu/cotton/), or have promise as new cultivars for Georgia growers (and are projected to be commercially available within 1-2 years).

Insect densities were enumerated for 8-weeks of the fruiting period, beginning in mid-July, by examining 25 squares and plant terminals per plot for the presence of lepidopteran eggs and larvae. Insect densities were unusually low in 2001, such that thresholds to trigger an insecticide application for control of lepidopteran pest insects on either Bollgard or non-Bollgard cultivars were not met throughout the season. Thus, no insecticide treatments for lepidopteran control were applied to the trial in 2001. Temik (aldicarb) was applied at planting for control of thrips (*Frankliniella* spp.), and orthene was applied early over-the-top of cotton to alleviate thrip damage to plant terminals.

Two weed management systems Roundup Ready and non-Roundup Ready were imposed on the 16 cultivars as appropriate (Table 2). Herbicide regimes and post-emergence cultivation, if any, were defined based on prevalent grower practices in Georgia, and represent one possible weed management system in which the respective cultivar could be produced. The Roundup Ready system consisted of pendimethalin [*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine] (Prowl®, 0.75 lb ai/A) pre-plant incorporated, glyphosate [*N*-(phosphonomethyl)-glycine] (1 lb ai/A) overtop of 4-5 leaf cotton, followed by prometryn [N,N'-bis(1-methylethyl)-6-(methylthio)-1,3,5-triazine-2,4-diamine] (Caparol®, 1.2 lb ai/A) plus MSMA [monosodium salt of Methylarsonic acid] (2.0 lb ai/A) precision-directed at layby. The non-Roundup Ready system consisted of pendimethalin pre-plant incorporated, followed by prometryn plus MSMA directed at layby, identical to that in the Roundup Ready system. However, the non-Roundup Ready system also included pyrithiobac {2-chloro-6-[(4,6-dimethoxy-2-pyrimidinyl)thio]benzoic acid} (Staple®; 0.043 lb ai/A) plus fluometuron {N,N-dimethyl-*N*'-[3-(trifluoromethyl)phenyl]urea} (Cotoran; 1 lb ai/A) applied pre-emergence in a “14” band over the row immediately after planting. When the non-Roundup Ready cotton was in the 4-5 leaf stage, MSMA (2 lb ai/A) was post-emergence-directed on a “14” band to the base of the cotton plants, while cultivating between cotton rows. All herbicide applications in the Roundup Ready system were applied broadcast with a total herbicide cost of $23.37 per acre, while the non-Roundup Ready system cost $27.77 per acre for the herbicides. The expense for cultivation and herbicide application costs are included in total production costs for the respective weed management system. Efficacy of weed management was rated several times over the growing season. Weed species were not seeded therefore only natural densities of weeds were present. Yellow nutsedge and smallflower morninglory were observed sporadically throughout the trial.

Seed costs, including technology fees for the transgenic cultivars, were determined considering 36-inch row spacing, 3-4 seed per foot of row, and the seed size (seed/lb) for each cultivar (obtained from cultivar owner). Seed cost for the non-transgenic cultivars averaged $9.32 per acre, $18.29 per acre for the Roundup Ready cultivars, $38.68 per acre for the Bollgard cultivars, and $45.13 per acre for the stacked cultivars. Seed costs for each cultivar in the trial are listed in Table 4.

No differences in maturity among cultivars were observed, thus all were defoliated at the same time. Subsequently, the center four rows of each 6-row plot were machine harvested on 9/28/01 and weighed to determine seed-cotton yields. Following machine harvest, two replicates of seed-cotton for each cultivar were combined into one sample to give sufficient (ca. 50 lbs) seed-cotton for ginning purposes. Seed-cotton samples were shipped to the USDA-ARS Cotton Ginning Laboratory, Stoneville, MS for determination of gin turnout and classing data. Seed-cotton samples were dried to constant moisture and ginned through the standard 'picker harvested cotton' seed-cotton cleaning, ginning, and lint cleaning steps as defined by Stanley Anthony, Supervisory Agricultural Engineer, USDA-ARS. As of January 2002 the fiber classing data was not available, therefore net returns for each cultivar *do not* reflect fiber discounts or premiums imposed by the marketing system.

Results and Discussion

The cultivars Stoneville 4691B, Stoneville 4892BR, FiberMax 966B, Deltapine 555BR, FiberMax 989, Deltapine Nucotn 33B, and Deltapine 458BR were the highest yielders in the trial, while Deltapine 555BR had the highest gin turnout (Table 1). Deltapine 555BR, FiberMax 966B, and Stoneville's 4691B and 4892BR are new or relatively new cultivars that show promise for Georgia growers in the next few years. All seven highest yielding cultivars in this systems trial also performed well in the 2001 University of Georgia Official Cultivar Trials at Athens, Bainbridge, Midville, Plains, and Tifton. Insect densities were unusually low in 2001 at the Tifton, GA trial site. Densities of lepidopteran insects never triggered an insecticide application for their control on either Bollgard or non-Bollgard cultivars, thus we could not effectively compare insect control costs under more normal pest insect pressure between these insect management systems. Weed management was excellent with either the Roundup Ready or non-Roundup Ready herbicide regimes. Yellow nutsedge and smallflower morningglory were observed sporadically in the trial prior to applications of herbicides. Thereafter, weed densities remained low. The Roundup Ready herbicide regime was cheaper ($23.37/acre total herbicide system cost) compared with the non-Roundup Ready system ($27.77/acre total herbicide system cost). The Roundup Ready herbicide regime also had lower costs for machinery use over the season (Table 4).

Net returns averaged $536.43/acre for Roundup Ready cultivars, while stacked (Bollgard plus Roundup Ready) cultivars returned an average of $584.76/acre (Table 3). Low densities of insect and weed pests prohibited us from separating cultivars and types (e.g., transgenic or not) on the basis of efficacy of pest management (Table 4). In the absence of insect and weed pests, net returns in this trial were more related to yield potential of the background genotype than to presence of transgenically mediated, pest management, traits. As of this writing, HVI fiber data was not yet available, thus discounts or premiums imposed by the marketing system could not be factored into net returns for each cultivar. Based on HVI fiber data collected in the University of Georgia Official Cultivar Trials, we expect cultivar variation in fiber properties and perhaps color/trash grades to slightly alter net returns for cultivars we studied. These data will be updated, hopefully, by the first quarter report of 2002.

In summary, stacked (Bollgard plus Roundup Ready) cultivars produced the highest returns. Net return in this trial was more related to yield potential of the background genotype than to presence of transgenically mediated, pest management traits. These data from at least two years and combined with that from OCTs can assist growers in choosing cultivars and production systems to optimize profits.

References

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Table 1. Statistical analysis of gin turnouts and lint yield for 16 cotton cultivars produced according to their respective pest management system at Tifton, GA in 2002.

Cultivar	Gin Turnout %	Lint Yield lb/acre
STONEVILLE4691B	36.5	**1384**
STONEVILLE4892BR	36.3	**1351**
FIBERMAX966B	37.4	**1324**
DP555BR	39.7	**1316**
FIBERMAX989	36.3	**1300**
DPNUCOTN33B	34.5	**1277**
DP458BR	35.7	**1277**
FIBERMAX989BR	35.4	1248
DP5415R	36.6	1215
DP448B	35.7	1201
STONEVILLE580	35.4	1193
PHYTOGENGA161	34.5	1175
FIBERMAX989R	37.4	1173
DPDELTAPEARL	37.3	1170
STONEVILLE4793R	37.2	1131
SUREGROW521R	35.6	1112
LSD0.10	**0.8**	**135**
CV %	1.2	9.2

Highest yielders not significantly different.

Table 2. Details of Roundup Ready and non-Roundup Ready herbicide systems applied to cultivars in cultivar x systems trial in 2001 at Tifton, GA.

Roundup Ready Herbicide System			
HERBICIDE	**APPLICATION METHOD**	**RATE**	**COST/A ($)**
PROWL	PRE-PLANT INCORPORATED	1.8 PINT/A	3.78
Roundup	OVERTOP @ 4-5 LEAF	1.6 QT/A	6.7
CAPAROL+MSMA	POST-DIRECTED BROADCAST	2.4 + 2.5 PINT/A	8.04+4.85
		TOTAL COST	**23.37**

Non-Roundup Ready Herbicide System			
HERBICIDE	**APPLICATION METHOD**	**RATE**	**COST/A ($)**
PROWL	PRE-PLANT INCORPORATED	1.8 PINT/A	3.78
COTORAN+STAPLE	AT PLANT-BANDED	0.8 QT/A + 0.3 OZ/A	3.22+6.00
MSMA	POST-DIRECTED-BANDED	0.97 PINT/A	1.88
CAPAROL+MSMA	POST-DIRECTED BROADCAST	2.4 + 2.5 PINT/A	8.04+4.85
		TOTAL COST	

Table 3. Average net return for four cotton production systems each imposed on four cultivars as appropriate.

Production System†	Average Cost $/A	Net Return $/A‡
Non-transgenic	84.60	563.69
B	113.96	580.96
R	84.12	536.43
BR	110.97	584.76

†Cotton production systems categorized by insect and weed pest management protocol. Non-transgenic=traditional pesticides applied for insect and weed management; B=Monsanto Bollgard lepidopteran insect management production system; R=Monsanto glyphosate herbicide tolerance weed management system; BR=both transgenic pest management systems applied.

‡For net return by cultivar and system see Table 4.

Table 4. Cultivar, lint yield, income, production costs by source, and net returns for 16 cotton cultivars grown according to non-transgenic or transgenic production systems.

			Costs				Total	Net
Cultivar*	**Yield†**	**Income‡**	**Seed§**	**Herbicide**	**Insect††**	**Equipment**	**Cost $/A**	**Return $/A**
DP DeltaPearl	1170	627.12	8.47	27.77	10.43	37.09	83.76	543.36
FM 989	1300	696.80	10.80	27.77	10.43	37.09	86.09	610.71
PSC GA 161	1175	629.80	8.64	27.77	10.43	37.09	83.93	545.87
ST 580	1193	639.45	9.35	27.77	10.43	37.09	84.64	554.81
DP 448B	1201	643.74	36.63	27.77	10.43	37.09	111.92	531.82
DP 33B	1277	684.47	36.54	27.77	10.43	37.09	111.83	572.64
FM 966B	1324	709.66	40.53	27.77	10.43	37.09	115.82	593.85
ST 4691B	1384	741.82	41.00	27.77	10.43	37.09	116.29	625.54
DP 5415R	1215	651.24	16.55	23.37	10.43	32.03	82.38	568.86
FM 989R	1173	628.73	20.00	23.37	10.43	32.03	85.83	542.89
ST 4793R	1131	606.22	17.51	23.37	10.43	32.03	83.34	522.87
SG 521R	1112	596.03	19.09	23.37	10.43	32.03	84.92	511.11
DP 555BR	1316	705.38	44.65	23.37	10.43	32.03	110.48	594.89
DP 458BR	1277	684.47	43.12	23.37	10.43	32.03	108.95	575.52
FM 989 BR	1248	668.93	45.60	23.37	10.43	32.03	111.43	557.49
ST 4892BR	1351	724.14	47.16	23.37	10.43	32.03	112.99	611.14

*DP=Deltapine; FM=FiberMax®; PSC=Phytogen; ST=Stoneville Pedigreed Seed®; B=cultivar contains Monsanto Bollgard gene for lepidopteran insect control; R=cultivar contains Monsanto glyphosate tolerance gene.

†Lint yield/acre determined by multiplying plot seed-cotton yield by mean gin turnout.

‡Income/acre determined by multiplying fiber price determined from cash price plus loan deficiency payment ($0.536 as of this writing). Does not include any discounts or premiums imposed by the loan schedule based on classing office fiber data (Classing office data not yet available).

§Seed cost/acre figured through number seed per pound and desired stand of 2-3 plants per row foot by seeding 3-4 per row foot.

††Insect control costs same for Bollgard and non-Bollgard cultivars at Tifton in 2001 because pest insects never reached threshold for control on either cultivar type. Costs listed are for Temik and Orthene to control thrip insects.