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AN ECONOMIC COMPARISON OF TRANSGENIC AND NON-TRANSGENIC COTTON PRODUCTION SYSTEMS IN ARKANSAS

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Abstract

Representative non-transgenic, and transgenic Roundup Ready®, BXN®, Bollgard®, and Roundup Ready plus Bollgard cotton cultivars, were planted at the Northeast Research and Extension Center (Keiser, AR) and the Southeast Branch Experiment Station (Rohwer, AR) in 2001, 2002 and 2003. All plots were managed to maximize yields by utilizing the genetic capabilities for each cultivar. The results show a trend for the highest yielding cultivars to produce the greatest net returns. However, in instances where yield differences were relatively small, costs determined profitability. At Keiser, the Roundup Ready system was the least expensive in all three years. At Rohwer, the Roundup Ready system was the most cost effective in 2001 and 2003, while the non-transgenic system was the least costly in 2002. The Bollgard system was not a cost effective means of insect control at either location in any year. However, high yields with some of the Bollgard cultivars produces high gross returns and made these systems profitable No clear indication of one cotton production system being more economical than another was observed.

Introduction

Transgenic cotton cultivars provide growers with additional management options for weed and insect control. Growers now have the option to plant Bollgard cultivars that express an organic toxin synthesized by the bacterium, *Bacillus thuringiensis* (*Bt*). *Bt* cultivars express the toxin in the foliage, bracts and carpels. When certain lepidopteran pests, notably the heliothine insects, tobacco budworm (Heliothis virescens) and cotton bollworm (Helicoverpa zea) feed on Bollgard cotton the Bt toxin paralyzes the mid-gut of susceptible insects and they die as small caterpillars (Benedict, 1996). Other transgenic cultivars have been developed that have the ability to withstand non-selective herbicides such as glyphosate (Roundup Ready) or bromoxynil (BXN) (Collins, 1996; Stewart, 1996). Newer cultivars have incorporated both the herbicide resistance and *Bt* expressions in order to provide both insect and weed management capabilities.

These new transgenic cultivars have been widely accepted by producers. In 2002, the USDA-AMS Cotton Division reported that approximately 94% of the cotton acreage in Arkansas was planted to transgenic cultivars (USDA-AMS, 2002). More specifically, 3% was planted to *Bt*, 7% was planted to BXN, 27% was planted to Roundup Ready, and 55% was planted to *Bt* + Roundup Ready cultivars.

Although these cultivars are widely adapted among growers, they have undergone only limited publically available research that evaluates their overall agronomic and economic performance (Bourland et al., 1997). Early research evaluating *Bt* cotton primarily had an entomological focus. A similar narrow focus on weed control and cotton tolerance was also observed with the BXN and Roundup Ready cultivars. There is current need for systems level research evaluating how these cultivars will perform under a wide variety of pest complexes and cultural methods and to compare their costs, gross, and net returns to the grower.

Methods

Field studies were initiated in 2001, 2002 and 2003 at the Northeast Research and Extension Center (NEREC) at Keiser, AR and the Southeast Branch Experiment Station (SEBES) at Rohwer, AR. Cotton was planted on May 15, 2001; May 31, 2002 and May 28, 2003 at NEREC and on June 7, 2001; May 21, 2002 and May 12, 2003 at SEBES. Plot size was 4 rows 0.9 m by 15 m long. The experimental design was a randomized complete block with 4 replications. The plots at the NEREC were managed under a no-till system. The plots at the SEBES were managed using a more conventional system of spring tillage and mechanical cultivations when appropriate.

Roundup Ready, BXN, *Bollgard*, and Roundup Ready plus Bollgard cultivars, were chosen based on their performance in the University of Arkansas Official Variety Tests (Benson et al. 2001) and percentage of acreage planted in Arkansas (UDSA-AMS, 2001). The cultivars included in the study by year are listed in Table 1.

All plots were managed to maximize yields according to University of Arkansas Cooperative Extension Service recommendations. Herbicide systems were chosen based on the genetic capabilities for each cultivar. For example, Roundup UltraMax® was the primary herbicide for Roundup Ready and Roundup Ready plus Bollgard cultivars, Buctril herbicide was used for BXN 47®, and cotton-selective herbicides were used with non-transgenic cultivars. After emergence, plots were scouted for insects weekly. As with the herbicide systems, insecticide applications were based on the genetic capabilities of each cotton cultivar. At both locations, the two center rows of each plot were machine harvested.

Plot yields were multiplied by the base Arkansas Commodity Credit Corporation loan rate to arrive at gross returns for each treatment. The base loan rate was $0.5230/lb in 2001, $0.524/lb in 2002 and $0.5235/lb in 2003. Treatment costs including seed, technology fees, herbicide, insecticide, and application costs were determined for each cultivar. These expenses were subtracted from gross returns to calculate the returns over treatment cost per cultivar.

Results and Discussion

Yields

In 2001, no significant differences were observed in yield at the NEREC, while at the SEBES, the cultivars 'SG 215 BR', 'ST 4892 BR', and 'DPL 20 BG' produced higher yields than did several of the others.

In 2002, Paymaster '1199 RR' was numerically the highest yielding cultivar at both locations. However at the NEREC, 'PM 1218 BR', SG 215 BR and DPL20 BG produced as much lint as did Paymaster 1199 RR, and at SEBES, seven other cultivars produced yields that did not significantly differ from that of Paymaster 1199 RR (Tables 2 and 3). Stoneville BXN 47 yielded at or near the bottom at both locations. Three of the top four yielding cultivars at NEREC contained the Roundup Ready gene. Two of the three lowest yielding cultivars at SEBES contained the Roundup Ready gene.

In 2003, Phytogen 355 was the numerically highest yielding cultivar at NEREC, with four other cultivars not significantly different in yield (Table 6). Stoneville 5599BR was the numerically highest yielding cultivar at SEBES and Phytogen 355 was not significantly different in yield (Table 7).

Pest Management Costs, Gross, and Net Returns

Economic information for all cultivars at both locations in each year is displayed in Tables 2 through 7. The results show a tendency for the highest yielding cultivars to produce the greatest returns. However, in some instances, the yields and returns are very close, and in such instances the costs affect the ranking of net returns among some of the varieties.

At NEREC, the Roundup Ready system was least expensive in all three years. At SEBES, the Roundup Ready system was the cheapest in 2001 and 2003, while the system using non-transgenic cultivars and cotton-selective herbicides was the least costly in 2002.

The Bollgard system was not the least costly system of insect management at either location in any year. Savings on insecticides and application were not sufficient to offset the increased cost of technology and seed. However, some cultivars containing the Bollgard gene were advantageous in some years because of their high yields. Differences in herbicide and insecticide costs from year to year are an indication of the variability in weed and insect pressure across years.

Eight of the cultivars were grown in all three years. The annual returns and the three-year average for these cultivars are displayed in Tables 8 and 9. It is clear that no one cultivar had the greatest return each year and that differences between cultivars do exist within years. However, over the long run, as expressed by the three-year averages, differences between some cultivars are relatively small. No single cultivar or type of production system stands out as always resulting in the greatest return. Choosing the cultivar with the greatest return in a given year ex-ante would be difficult. Most likely a mix of cultivars would provide the producer with an acceptable average return and a reduction in variability.

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Table 1. Cotton cultivars serving as treatments and year of their inclusion.

Stoneville ST 474 [123]	FiberMax FM 966 [123]	Paymaster PM 1218 BR [2]
Stoneville ST 4793 R [123]	PhytoGen PSC 355 [123]	Suregrow 521 R [3]
Stoneville ST 4892 BR [123]	Suregrow SG 215 BR [123]	Fibermax 958 B [3]
Stoneville ST 4691 B [123]	Paymaster PM 1199 R [12]	Stoneville 5599 BR [3]
Stoneville BXN 47 [123]	Deltapine 20 B [12]	

[1] Planted in '01.
[2] Planted in '02.
[3] Planted in '03.

Table 2. Yields, revenues, treatment costs and returns, Northeast Arkansas (NEREC [a]) 2001.

Cultivar	Yield [b]	Revenue [c]	Herbicide Costs	Insecticide Costs	Tech Fee and Seed Costs	Application Costs	Combined Costs	Returns [d]
SG 215BR	1220 a	$638.06	$48.69	$34.51	$47.12	$27.53	$157.85	$480.21
ST BXN47	1154 a	$603.54	$72.12	$34.51	$17.60	$27.53	$151.76	$451.78
FIBERMAX 966	1146 a	$599.36	$83.46	$34.51	$11.55	$27.53	$157.05	$442.31
Phytogen 355	1136 a	$594.13	$83.46	$34.51	$11.00	$27.53	$156.50	$437.63
ST 4793R	1079 a	$564.32	$48.69	$34.51	$21.25	$27.53	$131.98	$432.34
PM 1199R	1056 a	$552.29	$48.69	$34.51	$20.35	$27.53	$131.08	$421.21
ST 4892BR	1063 a	$555.95	$48.69	$34.51	$51.04	$27.53	$161.77	$394.18
DPL 20B	1097 a	$573.73	$83.46	$34.51	$39.36	$27.53	$184.86	$388.87
ST 474	1043 a	$545.49	$83.46	$34.51	$12.10	$27.53	$157.60	$387.89
ST 4691B	1095 a	$572.69	$83.46	$34.51	$40.26	$27.53	$185.76	$386.93

[a] NEREC: Northeast Research and Extension Center, Keiser, AR;
[b] Means followed by the same letter within a column are not significantly different according to Duncan's Multiple Range Test (P=0.05).
[c] Revenue calculated using a loan value of $0.523/lb.
[d] Returns above cultivar, weed, and insect management costs.

Table 3. Yields, revenues, treatment costs and returns, Southeast Arkansas (SEBES [a]) 2001.

Variety	Yield [b]	Revenue [c]	Herbicide Costs	Insecticide Costs	Tech Fee and Seed Costs	Application Costs	Combined Costs	Returns [d]
SG 215BR	1025 a	$536.08	$37.28	$63.79	$45.17	$28.35	$174.59	$361.49
ST 4892BR	973 ab	$508.88	$37.28	$63.79	$48.98	$28.35	$178.40	$330.48
FIBERMAX 966	879 bc	$459.72	$94.16	$63.79	$10.50	$28.54	$196.99	$262.73
ST 4793R	776 cd	$405.85	$37.28	$63.79	$19.72	$28.35	$149.14	$256.71
ST 474	846 bcd	$442.46	$94.16	$63.79	$11.00	$28.54	$197.49	$244.97
DPL 20B	885 abc	$462.86	$94.16	$63.79	$37.79	$28.54	$224.28	$238.58
ST BXN47	822 cd	$429.91	$83.21	$63.79	$16.00	$28.54	$191.54	$238.37
PM 1199R	704 d	$368.19	$37.28	$63.79	$18.91	$28.35	$148.33	$219.86
Phytogen 355	796 cd	$416.31	$94.16	$63.79	$10.00	$28.54	$196.49	$219.82
ST 4691B	819 bc	$428.34	$94.16	$63.79	$38.60	$28.54	$225.09	$203.25

[a] SEBES: Southeast Branch Experiment Station, Rohwer, AR.
[b] Means followed by the same letter within a column are not significantly different according to Duncan's Multiple Range Test (P=0.05).
[c] Revenue calculated using a loan value of $0.5230/lb.
[d] Returns above cultivar, weed, and insect management costs.

Table 4. Yields, revenues, treatment costs and returns, Northeast Arkansas (NEREC [a]) 2002.

Variety	Yield [b]	Revenue [c]	Herbicide Costs	Insecticide Costs	Tech Fee and Seed Costs	Application Costs	Combined Costs	Returns [d]
PM 1199R	992 a	$519.81	$42.18	$31.34	$20.35	$21.85	$115.72	$404.09
PM 1218BR	908 ab	$475.79	$42.18	$16.89	$46.40	$17.85	$123.32	$352.47
SG 215BR	906 ab	$474.74	$42.18	$16.89	$47.12	$17.85	$124.04	$350.70
DPL 20B	890 abc	$466.36	$68.58	$16.89	$39.36	$17.85	$142.68	$323.68
Phytogen 355	873 bc	$457.45	$68.58	$31.34	$11.00	$21.85	$132.77	$324.68
ST 4691B	872 bc	$456.93	$68.58	$16.89	$40.26	$17.85	$143.58	$313.35
ST 4793R	849 bc	$444.88	$42.18	$31.34	$21.25	$21.85	$116.62	$328.26
ST 4892BR	838 bc	$439.11	$42.18	$16.89	$51.04	$17.85	$127.96	$311.15
FIBERMAX 966	811 bcd	$424.96	$68.58	$31.34	$11.55	$21.85	$133.32	$291.64
ST BXN47	788 cd	$412.91	$56.38	$31.34	$17.60	$21.85	$127.17	$285.74
ST 474	716 d	$375.18	$68.58	$31.34	$12.10	$21.85	$133.87	$241.31

[a] NEREC: Northeast Research and Extension Center, Keiser, AR;
[b] Lint yield determinations based on 39%. Means followed by the same letter within a column are not significantly different according to Duncan's Multiple Range Test (P=0.05).
[c] Revenue calculated using a loan value of $0.524/lb.
[d] Returns above cultivar, weed, and insect management costs.

Table 5. Yields, revenues, treatment costs and returns, Southeast Arkansas (SEBES [a]) 2002.

Variety	Yield [b]	Revenue [c]	Herbicide Costs	Insecticide Costs	Tech Fee and Seed Costs	Application Costs	Combined Costs	Returns [d]
PM 1199R	2014 a	$1,055.34	$32.77	$28.13	$18.91	$15.09	$94.90	$960.44
ST 4691B	1967 a	$1,030.71	$32.77	$28.13	$38.60	$15.09	$114.59	$916.12
ST 474	1948 a	$1,020.75	$32.77	$28.13	$11.00	$15.09	$86.99	$933.76
PhytoGen 355	1922 ab	$1,007.13	$32.77	$28.13	$10.00	$15.09	$85.99	$921.14
ST 4892BR	1896 ab	$993.50	$32.77	$28.13	$48.98	$15.09	$124.97	$868.53
DPL 20B	1867 abc	$978.31	$32.77	$28.13	$37.79	$15.09	$113.78	$864.53
PM 1218 BR	1836 abc	$962.06	$32.77	$28.13	$44.45	$15.09	$120.44	$841.62
FIBERMAX 966	1787 abc	$936.39	$32.77	$28.13	$10.50	$15.09	$86.49	$849.90
ST 4793R	1649 bc	$864.08	$32.77	$28.13	$19.72	$15.09	$95.71	$768.37
SG 215BR	1644 bc	$861.46	$32.77	$28.13	$45.17	$15.09	$121.16	$740.30
ST BXN47	1588 c	$832.11	$32.77	$28.13	$16.00	$15.09	$91.99	$740.12

[a] SEBES: Southeast Branch Experiment Station, Rohwer, AR.
[b] Lint yield determinations based on 39%. Means followed by the same letter within a column are not significantly different according to Duncan's Multiple Range Test (P=0.05).
[c] Revenue based on $0.524/lb.
[d] Returns above cultivar, weed, and insect management costs.

Table 6. Yields, revenues, treatment costs and returns, Northeast Arkansas (NEREC [a]) 2003.

Cultivar	Yield [b]	Revenue [c]	Herbicide Costs	Insecticide Costs	Tech Fee and Seed Costs	Application Costs	Combined Costs	Returns [d]
PSC 355	583 a	$305.20	$38.57	$13.77	$11.00	$13.81	$77.15	$228.05
SG 521R	519 abc	$271.70	$17.74	$13.77	$27.61	$13.81	$72.93	$198.77
ST 4793R	475 bcd	$248.66	$17.74	$13.77	$21.25	$13.81	$66.57	$182.30
ST 5599BR	527 abc	$275.88	$17.74	$13.77	$50.27	$13.80	$95.58	$180.30
ST 4691B	539 ab	$282.17	$38.57	$13.77	$40.26	$13.80	$106.40	$175.77
St 4892BR	505 abc	$264.37	$17.74	$13.77	$51.04	$13.80	$96.35	$168.02
ST 474	463 bcd	$242.38	$38.57	$13.77	$12.10	$13.80	$78.24	$164.14
ST BXN 47	429 cd	$224.58	$26.37	$13.77	$17.60	$13.80	$71.54	$153.04
SG 215BR	450 bcd	$235.58	$17.74	$13.77	$47.12	$13.82	$92.45	$143.13
FM 966	401 d	$209.92	$38.57	$13.77	$11.55	$13.80	$77.69	$132.23
FM 958B	458 bcd	$239.76	$38.57	$13.77	$42.79	$13.81	$108.94	$130.82

[a] NEREC: Northeast Research and Extension Center, Keiser, AR;
[b] Means followed by the same letter within a column are not significantly different according to Duncan's Multiple Range Test (P=0.05).
[c] Revenue calculated using a loan value of $0.5235/lb.
[d] Returns above cultivar, weed, and insect management costs.

Table 7. Yields, revenues, treatment costs and returns, Southeast Arkansas (SEBES [a]) 2003.

Variety	Yield [b]	Revenue [c]	Herbicide Costs	Insecticide Costs	Tech Fee and Seed Costs	Application Costs	Combined Costs	Returns [d]
ST 5599BR	1571 a	$794.15	$38.95	$32.63	$48.10	$27.62	$147.30	$646.85
PSC 355	1398 ab	$731.85	$70.41	$47.73	$10.00	$31.63	$159.47	$572.38
ST 474	1374 bc	$719.29	$70.41	$47.43	$11.00	$31.63	$160.47	$558.82
ST 4892BR	1337 bcd	$699.92	$38.95	$32.63	$48.98	$27.62	$148.18	$551.74
FM 958B	1363 bcd	$713.53	$70.41	$32.63	$40.90	$27.63	$171.57	$541.96
ST 4691B	1346 bcd	$704.63	$70.41	$32.63	$38.60	$27.63	$169.27	$535.36
FM 966	1297 b-e	$678.98	$70.41	$47.43	$10.50	$31.63	$159.97	$519.01
SG 215BR	1262 c-f	$660.66	$38.95	$32.63	$45.17	$27.62	$144.37	$516.29
ST BXN 47	1240 def	$649.14	$59.89	$47.43	$16.00	$31.63	$154.95	$494.19
ST 4793R	1163 fg	$608.83	$38.95	$47.43	$19.72	$31.62	$137.72	$471.11
SG 521R	1084 g	$567.47	$38.95	$47.43	$25.70	$31.62	$143.70	$423.77

[a] SEBES: Southeast Branch Experiment Station, Rohwer, AR.
[b] Means followed by the same letter within a column are not significantly different according to Duncan's Multiple Range Test (P=0.05).
[c] Revenue based on $0.5235/lb.
[d] Returns above cultivar, weed, and insect management costs.

Table 8. Returns[a] across years and average, Northeast Arkansas (NEREC).

Cultivar	2001	2002	2003	Avg.
PSC 355	$437.63	$324.68	$228.05	$330.12
SG 215BR	$480.21	$350.70	$143.13	$324.68
ST 4793R	$432.34	$328.26	$182.09	$314.23
St BXN 47	$451.78	$285.74	$153.04	$296.85
ST 4691B	$386.93	$313.35	$175.77	$292.02
ST 4892BR	$394.18	$311.15	$168.02	$291.12
FM 966	$442.31	$291.64	$132.22	$288.72
ST 474	$387.89	$241.31	$164.14	$264.45

[a] Returns above cultivar, weed, and insect management costs.

Table 9. Returns[a] across years and average, Southeast Arkansas (SEBES).

Cultivar	2001	2002	2003	Avg.
StT 4892BR	$330.48	$868.53	$551.74	$583.58
St 474	$244.97	$933.76	$558.82	$579.18
PSC 355	$219.82	$921.14	$572.38	$571.11
ST 4691B	$203.25	$916.12	$535.36	$551.58
FM 966	$262.73	$849.90	$519.01	$543.88
SG 215BR	$361.49	$740.30	$516.29	$539.36
ST 4793R	$256.71	$768.37	$471.11	$498.73
ST BXN 47	$238.37	$740.12	$494.19	$490.89

[a] Returns above cultivar, weed, and insect management costs.