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COTTON VARIETIES PLANTED IN ARKANSAS, 1995-2004

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Abstract

Since the introduction of a transgenic cotton variety to Arkansas in 1995, a major shift in varieties has occurred – with transgenic varieties accounting for 99% of acreage in 2004. The objectives of this paper were to compare variety types and dominate varieties grown in north and south Arkansas over a 10-year period, to compare brands of cottonseed planted since 1995, and to evaluate the relationship between variety test yield data and planted acreage in Arkansas. Data for planted acreage of varieties in Arkansas (1995 through 2004) and for north and south Arkansas were summarized by variety and variety type (conventional, Bt, RR, BR, BXN, LL). Planted acreage of varieties each year was then correlated to lint yield in the Arkansas Cotton Variety Test in the previous year. Arkansas producers have chosen to shift dramatically to transgenic varieties. Over the past 10 years, varieties planted in Arkansas have changed from exclusively conventional to nearly exclusively transgenic. Varieties planted in south Arkansas differed greatly from those planted in north Arkansas. South Arkansas producers tend to plant a wider array of varieties and used a higher percentage of later maturing varieties. Stoneville and Delta & Pine Land Company have dominated the Arkansas cottonseed market in the past decade by occupying approximately 95% of all acreage planted. Lint yield from the previous year of Arkansas cotton variety test did not have a consistent relationship with varieties planted in Arkansas. Arkansas producers use additional factors besides previous year lint yield (over all locations) of the variety to determine which varieties to plant.

Introduction

Variety types of cotton grown in Arkansas have shifted dramatically over the last 10 years (Fig. 1). Since the introduction of transgenic varieties to Arkansas in 1995, conventional varieties have declined from over 99% of Arkansas cotton acreage in 1995 to less than 1% in 2004. Such a rapid change in cotton varieties is unprecedented. Most of the first transgenic varieties were simply popular varieties (recurrent parents) with an additional gene inserted. Several studies showed that agronomic performances of the transgenic varieties were similar to their recurrent parent (Bourland et al. 1997; Bryant et al. 2003, May et al., 2003). To some degree, this led to quick acceptance of the new transgenic varieties, but also hindered improvement of agronomic performance since the genes were backcrossed into older, accepted varieties.

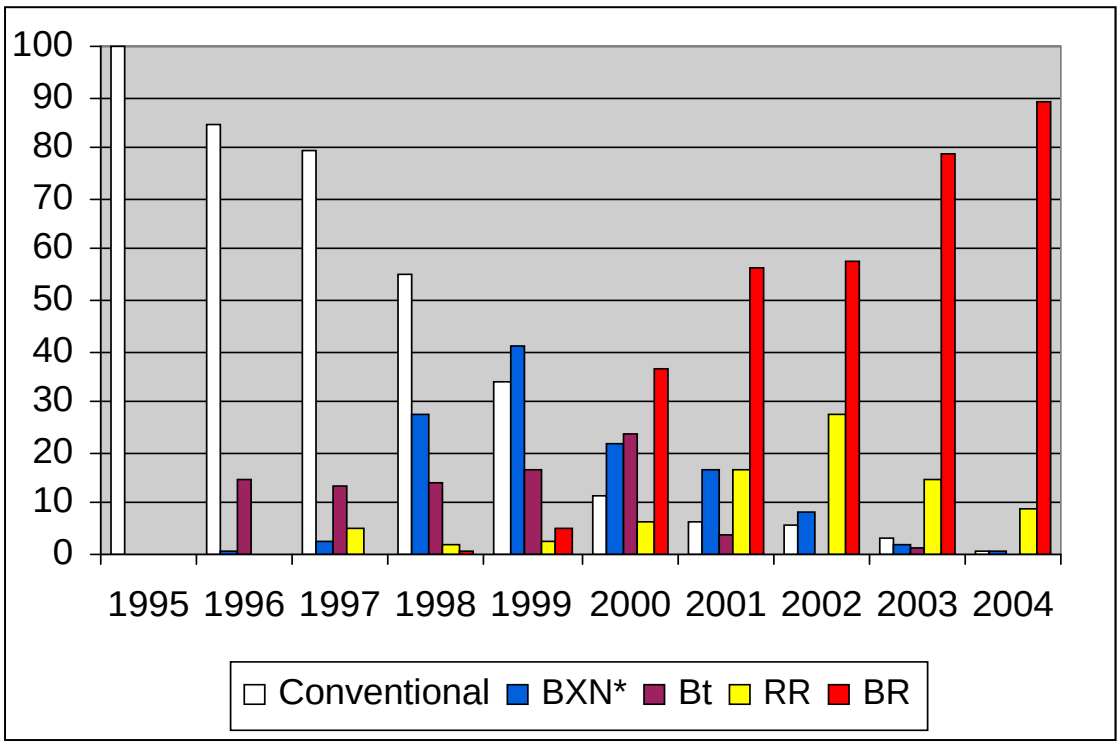

Fig.1. Arkansas cotton acreage (%) by variety type from 1995 through 2004.

Many of the first transgenic varieties were marketed on the basis of the performance of their recurrent parent. Although transgenic varieties do typically resemble their recurrent parent, small gene shifts during selection may alter the adaptation and performance of the transgenic variety. The transgenic variety 'H1560B' illustrates this point. In contrast to its recurrent parent 'H1560', 'H1560B' was much earlier maturing and was susceptible to root-knot nematode. Thus, transgenic versions of conventional varieties should be evaluated in the same manner as any new variety.

Many producers use official state variety test results when deciding which variety to plant. However, with the introduction of transgenic varieties, the presence of a particular transgene often became the primary factor in variety selection. Even if conventional varieties had highest yields in the variety test, producers limited their choices to transgenic varieties to facilitate insect and weed control.

The objectives of this paper were to compare variety types and dominant varieties grown in north and south Arkansas over the past 10 years, to compare brands of cottonseed planted in Arkansas over the past 10 years, and to evaluate the relationship between yield data from Arkansas Cotton Variety Test and planted acreage in Arkansas.

Material and Methods

Data for acreage planted to different cotton varieties were extracted from annual publications (1995 Crop through 2004 Crop) of "Cotton Varieties Planted" published by USDA, Agriculture Marketing Service, Cotton Division, Memphis, TN. Each year, the publication lists all varieties planted in Arkansas (and other states), and the top varieties planted are reported for each fiber classing office. From these data, the percentage of Arkansas acreage planted to specific variety types (i.e., conventional, BXN, Bt, RR, BR and LL) and to specific brands was determined for 1995 through 2004. Acreage in Hartz brand was combined with Paymaster brand. The top 10 varieties planted in north Arkansas (reported by Memphis Classing Office) and the top 10 varieties planted in south Arkansas (reported by Dumas Classing Office) were summarized.

Over the past 10 years, Arkansas Cotton Variety Tests have been conducted at six (seven in 2003) locations in the Delta region of Arkansas spanning ca. 200 miles north to south and different soil types. Each year, two non-irrigated tests were included and the rest were irrigated. Production management of the tests was accomplished by resident staff or by a cooperating producer. The test typically included standard varieties grown by producers and new varieties or lines, which may not be commercially available. Data were extracted from reports for the 1994 through 2003 tests which were published in Arkansas Agricultural Experiment Station Research Series 444, 454, 465, 473, 481, 491, 501, 513, and Special Report 185.

Simple correlation coefficients between lint yield of varieties in the Arkansas Cotton Variety Test and percentage of acreage by variety planted in Arkansas the following year were calculated. Lint yields by variety for 1994 through 2003 were correlated with percentage of acreage planted in Arkansas for 1995 through 2004, respectively.

Results and Discussion

Introduction of transgenic varieties

The first transgenic cotton variety grown in Arkansas was 'ST BXN 47' (0.3% of acreage in 1995). 'ST BXN 47', a Buctril® tolerant variety with 'ST 474' as its recurrent parent, was well-adapted to Arkansas. The strong performance of 'ST BXN 47' eased the way for other transgenic varieties to be quickly accepted. BXN varieties (primarily 'ST BXN 47') increased to more than 40% of Arkansas cotton acreage in 1999, but then declined rapidly (Fig. 1). The decline of BXN variety was primarily due to poor pigweed control associated with the BXN weed control program and the introduction of improved Round-up Ready® (RR) and stacked Bt/RR (BR) varieties.

Bt varieties (mainly 'NuCotn 33B') were widely planted (particularly in south Arkansas) in 1996, their first year of introduction (Table 1). 'NuCotn 33B' was planted to 36% of south Arkansas acreage in the same year (i.e., 1996) that it was first entered in the Arkansas Cotton Variety Test. Bt varieties had not been previously evaluated in official variety tests because of regulatory restrictions on genetic lines carrying the Bt or other transgene. Thus, producers accepted the variety before it was tested in any official state variety test. Difficult to control tobacco budworm (*Heliothis virescens* (F.) populations in 1995 provided the stimulus for this rapid acceptance of 'NuCotn 33B'. Due to its late maturity as well as less severe budworm problems, 'NuCotn 33B' was never planted greatly in north Arkansas. Acreage of all Bt varieties was relatively constant until 2001 when Bt acreage declined in favor of BR varieties (Fig. 1).

Introduced in 1997, acreage of RR varieties declined in 1999 and 2000 due to bronze wilt susceptibility in dominant RR varieties (particularly RR varieties having 'PM1215' or 'PM1220' as their recurrent parents). With additional RR varieties introduced, acreage of RR varieties increased in 2001 and 2002, then again declined in 2003 and 2004 in favor of better performing BR varieties as well as the influence of Boll Weevil Eradication Program (BWEP). Frequent insecticide applications associated with initiation of the BWEP reduced predacious control of boll worms - thus enhancing the value of Bt gene in varieties.

Acreage in BR varieties has steadily increased in Arkansas since they were introduced in 1997 (Fig. 1). In 2004, BR varieties occupied nearly 90% of Arkansas acreage. 'PM 1218 BR', 'ST 4892 BR' and 'DP 451 BR' were the first successful BR varieties in Arkansas. When introduced, BR varieties tended to perform better than Bt and RR varieties developed from the same recurrent parents.

Liberty Link (LL) varieties were introduced to Arkansas in 2004 (acreage included with BXN* acreage in Fig. 1). LL varieties provide a different weed control system which may become important as glyphosate resistance becomes established in some native weed populations.

Cotton varieties planted in south and north Arkansas

Cotton production differs greatly in the north and south Mississippi River Delta. South Arkansas cotton producers tend to have a longer growing season, higher insect pest pressure, and different weed pressures. Over the past 10 years, dominant varieties grown in north Arkansas (Table 1) have differed from those planted in south Arkansas (Table 2). With a longer growing season, south Arkansas producers tend to plant a higher percentage of later maturing varieties (e.g. 'LA 887', 'NC 33B', 'DP 458 B' and 'DP 555 BR') than do north Arkansas producers. High incidence of resistant budworms caused south Arkansas producers to quickly adopt varieties having Bt technology. Acreage of Bt (without RR gene) varieties grown has continued to be higher in south than in north Arkansas. Conversely, north Arkansas producers adopted BXN and RR (without Bt gene) technologies faster than did producers in south Arkansas.

Table 1. Acreage % of top 10 cotton varieties planted in north Arkansas from 1995 through 2004 (from Memphis Classing Office report).

Rank	1995	%	1996	%	1997	%	1998	%	1999	%
1	DP51	25	ST474	23	ST474	37	BXN47	37	BXN47	52
2	DP20	24	DP51	18	SG125	21	ST474	24	ST474	16
3	ST132	9	DP50	13	DP51	15	DP51	7	DP5111	6
4	DES119	8	DP20	13	PM1220RR	4	H1220	5	SG125	4
5	DP5409	7	SG125	10	DP20	4	ST373	5	DP51	4
6	DP50	5	DP5409	4	DP50	4	SG125	5	PM1220BR	3
7	ST453	5	ST132	3	BXN47	2	DP5409	3	DP20	2
8	HS46	3	DP5415	2	DP5409	2	PM1220RR	2	DP50	1
9	ST506	2	DP2156	2	PM1215RR	2	DP50	2	PM1220RR	1
10	ST474	2	NC33B	2	LA887	1	DP20	1	NC33B	0
Top3		58		55		74		68		74
Top5		73		78		81		78		81
Rank	**2000**	**%**	**2001**	**%**	**2002**	**%**	**2003**	**%**	**2004**	**%**

1	BXN47	46	PM1218BR	30	ST4793RR	29	ST4892BR	38	ST4892BR	33
2	PM1218BR	18	BXN47	21	PM1218BR	18	ST4793BR	16	DP444BR	16
3	ST474	6	ST4892BR	17	ST4892BR	14	PM1218BR	12	PM1218BR	14
4	DP436RR	5	ST4793RR	7	BXN47	11	SG215BR	11	ST4793RR	10
5	DP451BR	4	DP451BR	6	SG215BR	6	DP451BR	9	ST5599BR	9
6	DP425RR	3	DP425RR	4	DP451BR	5	ST5599BR	2	FM960BR	4
7	SG747	2	DP436RR	3	PM1199RR	4	DP436RR	1	SG215BR	2
8	ST4892BR	2	PM1199RR	3	SG521RR	3	PM1199RR	1	DP451BR	2
9	PM1220BR	1	PSC355	2	DP436RR	2	FM989BR	1	DP436RR	2
10	DP388	1	SG521RR	2	DP425RR	1	FM958	1	PM1199RR	1
Top3		70		68		61		66		63
Top5		80		81		78		86		82

Table 2. Acreage % of top 10 cotton varieties planted in south Arkansas from 1995 through 2004 (from Dumas Classing Office report).

Rank	**1995**	**%**	**1996**	**%**	**1997**	**%**	**1998**	**%**	**1999**	**%**
1	DP20	20	NC33B	36	NC33B	25	ST474	29	BXN47	27
2	DP51	17	DP50	14	ST474	24	BXN47	16	NC33B	20
3	DP50	15	DP20	13	SG125	9	NC33B	10	ST474	9
4	LA887	10	ST474	12	DP50	7	ST4740B	7	DP428B	7
5	SG501	9	SG125	9	DP20	7	SG125	6	SG747	6
6	DP5409	5	SG501	5	DP20B	5	DP20B	5	DP20B	5
7	SG404	4	DP51	3	SG501	4	DP20	5	SG125	4
8	ST474	4	DP5409	3	PM1215RR	3	DP50B	5	SG501	2
9	ST132	3	ST132	2	BXN47	0	DP32B	2	PM1220BR	1
10	ST453	3	LA887	1	PM1244	0	SG501	1	DP451BR	1
Top3		53		62		59		54		55
Top5		71		82		73		68		67
Rank	**2000**	**%**	**2001**	**%**	**2002**	**%**	**2003**	**%**	**2004**	**%**
1	BXN47	16	DP451BR	23	DP451BR	24	DP451BR	25	DP555BR	33
2	ST4691B	16	PM1218BR	17	AT4892BR	17	ST4892BR	18	ST5599BR	29
3	DP451BR	15	ST4892BR	17	SG215BR	14	PM1218BR	14	DP444BR	22
4	NC33B	12	BXN47	7	PM1218BR	10	SG215BR	10	PM1218BR	4
5	DP448B	10	SG501	4	ST4691B	5	DP555BR	7	DP451BR	3
6	PM1218BR	9	ST4793RR	3	DP436RR	4	ST4793RR	4	FM960BR	3
7	ST474	3	ST4691B	3	ST4793RR	3	FM989BR	4	ST4892BR	2
8	SG747	3	ST474	2	BXN49B	3	ST4691B	3	DP436RR	1
9	DP20B	2	DP436RR	2	DP458BR	2	ST5599BR	3	ST4793RR	1
10	SG125BR	2	SG747	2	PSC355	2	FM960BR	2	DP434RR	0
Top3		47		58		55		58		85
Top5		69		69		70		74		92

BR varieties are now dominant in both north and south Arkansas (Tables 1 and 2). Since 2002, at least two of the top three varieties grown in each region possessed the BR technology. As a group, BR varieties have tended to perform better than Bt or RR varieties. Due to lower technology fees, many north Arkansas producers would prefer RR over BR varieties. However, the higher performance of BR varieties and the initiation of BWEP (and subsequent disruption of beneficial insects) have caused BR varieties to be favored. As better RR varieties become available and BWEP progresses (less disruption of beneficial insects), RR and/or LL varieties will likely become more favored, particularly in north Arkansas.

In eight of the past 10 years, the top three and top five planted varieties occupied lower percentage of acreage in south compared to north Arkansas (Tables 1 and 2). The year 2004 is a notable exception with three varieties

occupying 85% of south Arkansas acreage. The wider diversity of varieties typically used in south Arkansas may be due to a greater number of adapted varieties available. Both early and late maturing varieties may be adapted to south Arkansas whereas most late maturing varieties do not perform well in north Arkansas.

The first transgenic varieties to occupy more than 10% of Arkansas cotton acreage were 'NuCotn 33B' in 1996, 'ST BXN47' in 1998 and 'PM 1218 BR' in 2000 (Tables 1 and 2). No RR variety (excluding stack gene BR varieties) has ever been planted to more than 10% of Arkansas cotton acreage.

Brands of cottonseed planted in Arkansas

Over the past 10 years, Stoneville has been the top brand of cottonseed grown in Arkansas (Table 3). The dominance of Stoneville brand has primarily been due to the performance of 'ST 474' used as either a conventional variety or as the recurrent parent of transgenic varieties ('ST BXN 47', 'ST 4793 RR', 'ST 4691 B', and 'ST 4892 BR').

Table 3. Percentage of Arkansas cotton planted to different cottonseed brands, 1995-2004.

	% acreage by year										
Brand	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Mean**
Stoneville	19.9	25.2	35.1	62.8	54.3	31.7	41.2	44.4	45.8	44.9	40.5
Deltapine	64.6	58.8	40.3	22.3	26.1	47.8	23.3	20.3	21.9	37.9	36.3
Paymaster	0.8	1.2	6.2	6.6	10.3	12.3	27.4	17.5	13.3	10	10.6
Sure-Grow	12.3	13.8	18.3	7.2	9	5.5	5.4	14.2	12.1	1.8	10.0
FiberMax						0.9	0.6	2.2	6.6	5.2	3.1
Phytogen					0.1	1.7	2	1.1	0.3		1.0
HyPerformer	0.8	0.2									0.5
SeedCo	0.4	0.1	0.1								0.2
Terra	0.3	0.1									0.2
AgriPro						0.1	0.1				0.1
BCG										0.1	0.1
Chembred	0.1	0.1									0.1

The three brands of Delta & Pine Land Company (Deltapine, Paymaster and Sure-Grow) have occupied more than half of the acreage in nine of the last 10 years (all except 1998). Stoneville and Delta & Pine Land Company brands accounted for more than 95% of Arkansas acreage from 1995 to 2002. In the past two years, acreage planted to FiberMax, Phytogen and Beltwide Cotton Genetics (BCG) varieties has tended to increase.

Top 10 yielding varieties in Arkansas Cotton Variety Tests, 1994-2003

Comparing lint yield over all locations of the Arkansas Variety Tests from 1994 through 2003, there has been ca. 10% difference in yield of the 1st and 10th highest yielding varieties (Table 4). Variety by location interaction was significant for yield each year (data not shown). Therefore, producers should examine variety performance in nearby location rather than yield over all locations. Lint yields of late maturing varieties tend to be low relative to short-season varieties in Arkansas Cotton Variety Tests. This may be associated with management of the tests or specific adaptation to test sites. The first transgenic variety to lead the Arkansas Cotton Variety Test was 'ST 4691 B' in 2001. Transgenic varieties now dominate the Arkansas Cotton Variety Test, occupying more than 90% of entries in the main test in 2004 (Bourland, 2005).

Table 4. Varieties with highest lint yields (over locations) in Arkansas Cotton Variety Tests from 1994 through 2003.

	1994		**1995**		**1996**		**1997**		**1998**	
Rk.	**Variety**	**lb/a**	**Variety**	**lb/a**	**Variety**	**lb/a**	**Variety**	**lb/a**	**Variety**	**lb/a**
1	SG223	1247	ST474	1008	H1244	1148	BXN47	1309	PSC355	1158
2	SG125	1243	H1220	973	ST139	1148	PM1560B	1308	PM1218BR	1139

3	SG404	1241	DP5415	949	PM1220R	1142	ST373	1276	PM1560B	1128
4	ST474	1231	SG125	945	ST474	1135	SG747	1262	DP5111	1099
5	DP5409	1176	H1215	936	PM1220B	1133	H1266	1254	SG890	1093
6	DES119	1171	H1244	929	BXN47	1116	ST474	1250	SG501	1092
7	H1215	1153	SG501	922	SG125	1114	PM1330B	1230	SG747	1076
8	DP20	1153	ST132	905	H1220	1106	DP5111	1227	PMX31746R	1076
9	STX94332	1153	DP5415	891	H1215	1095	GC251	1221	SG105	1073
10	SG501	1153	SG404	888	PM1560B	1081	SG501	1219	PM1220BR	1064

	1999		2000		2001		2002		2003	
Rk	**Variety**	**lb/a**	**Variety**	**lb/a**	**Variety**	**lb/a**	**Variety**	**lb/a**	**Variety**	**lb/a**
1	PSC355	1132	FM966	1053	ST4691B	1284	ST5599BR	1184	ST5599BR	1110
2	PM1218BR	1101	FM958	1047	SG215BR	1243	PH98M	1167	DP444BR	1097
3	SG105	1090	PSC355	1043	SG105	1222	DPx99x35	1128	ST4892BR	1043
4	SG747	1072	SG105	1012	SG747	1222	ST4892BR	1126	BXN49B	1013
5	PM1220BR	1061	ST4691B	981	FM958	1216	FM966	1123	Arkot9108	996
6	SG501	1047	DP388	973	ST4892BR	1165	DP491	1117	PSC355	970
7	AP7115	1044	SG747	967	SG501BR	1140	BXN49B	1103	Syn2429	957
8	PM1220BR	1035	PM1218BR	967	Ark8712	1125	ST457	1097	FM960BR	926
9	ST474	1035	ST4892BR	955	BXN47	1109	DP555BR	1094	SG521R	925
10	BXN47	1033	ST4793R	953	SG521R	1096	SG215BR	1087	FM958B	918

Relation of Lint Yield in Variety Test With Acreage Planted of Variety the Following Year

Lint yields of varieties in Arkansas Cotton Variety Tests (over all locations) in one year had no consistent effect of acreage of varieties planted in Arkansas (north and south combined) the following year (Table 5). Correlation Coefficients ranged from -0.28 in 1995 to +0.88 in 2004.

These low correlations were likely associated with several different factors including: 1) acreage planted may be linked closer to relative performance in local area rather performance across locations, 2) acreage planted may be linked closer to relative performance over multiple years rather than performance in a single year, 3) limited availability of seed for some high yielding varieties and lines (e.g. SG 223 which was never released), 4) limited availability of transgenic seed for some high yielding varieties, 5) low yields of some late maturing varieties in variety test (e.g. 'NC 33B'), and 6) factors other than variety test performance may determine planted acreage of a variety (e.g. promotion of variety, previous experience with variety, availability of seed, etc.). The high correlation of variety test yield in 2003 and planting acreage in 2004 suggests that newly developed top performing varieties have wide adaptability and acceptance.

Table 5. Correlation between lint yields of varieties in Arkansas Cotton Variety Tests (over all locations) in one year with acreage of varieties planted in Arkansas the following year (north and south Arkansas combined).

Parameter	**Years of data in correlation coefficient**									
Lint yield	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Acreage	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
r(yield:acreage	-0.26	+0.36	+0.14	+0.47	+0.06	-0.08	-0.41	+0.19	-0.03	+0.88

Conclusions

Arkansas producers have shifted from essentially no transgenic cotton varieties grown in 1995 to essentially all transgenic varieties in 2004. The order of transgenic types introduced to Arkansas was BXN in 1995, Bt in 1996, RR in 1997, BR in 1998 and LL in 2004. BXN and RR technology (both associated with weed control) was more quickly adopted in north Arkansas while Bt technology (associated with insect control) was more quickly adopted in south Arkansas. BR varieties now dominate variety types grown in north and south Arkansas. As improved RR and LL varieties become available, they will likely become favored - particularly by producers in north Arkansas. Many factors, including variety test results, determine which cotton varieties are preferred by Arkansas producers.

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