

**OBSOLETE CONVENTIONAL VS MODERN TRANSGENIC  
CULTIVARS PERFORMANCE EVALUATIONS**

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Many changes have taken place in the World cotton community in the last fifteen (15) years with changes continuing. Can the US cotton industry survive as a major producer and textile industry? Survival depends greatly on becoming more efficient in producing both the quantity and quality of cotton. One of the changes the US has made is moving from 100% conventional varieties in 1995 to 82.6% transgenic varieties in 2005 (Agricultural Marketing Service – Cotton, 2005). Transgenics introduced “added value” traits into cotton that previously were not available to breeders. These transgenes thus far have added genes that confer resistance to insects and herbicide tolerance. The backcross breeding method has been the primary US breeding method to produce transgenic varieties. This breeding method requires about five years to change a conventional variety into a marketable transgenic variety. The expected results are about the same yield and fiber quality of the recurrent conventional variety plus the added value traits. The questions are: after this change, what is happening to yield and fiber quality and can US cotton compete world wide by merely maintaining the yield and fiber quality of old varieties?

It is granted that transgenic Bt varieties have resulted in a decrease of crop losses in the Mississippi Delta of about 2% due to the worm complex and decreased the number of insecticides applied by about 3.5 per year. However, this has been partly compensated by increased crop losses due to plant bugs by 1.3% and increased insecticide applications by 2.3 per year (Crop Losses due to Insects, Beltwide Proceedings, 1986 – 2004) to control plant bugs.

Average Mississippi Delta yields (USDA Crop Reporting Service. 1981 – 2005) and fiber traits (Agr. Marketing Service – cotton. 1981 – 2005) have not been static for the last 25 years. As indicated in Figure 1, yields have increased at the rate of about 6.2 lbs per acre per year or about 0.8% per year. During this same period, fiber length has been decreasing at about 0.017 inch per year, or about 0.05% as shown in Figure 2. Figure 3 shows micronaire has been increasing by about 0.21 units per year or 0.5% and HVI strength has been increasing by 0.19 g/tex or 0.7% as indicated in Figure 4. Significant regressions of trait on year are indications of the contributions of grower utilization of ***all*** technology improvements. Such factors as boll weevil control, more efficient nutrient application, faster harvesting, ginning and varietal improvement are just a few of these technological changes.

How do you measure the contribution of transgenic varieties to these changes? The objective of this study was to compare in the same variety tests the performance of obsolete conventional varieties released prior to 1996 with the major transgenic varieties grown from 1996 to 2005.

Seventeen conventional and twelve transgenic varieties were grown at three locations near Stoneville in 2004 and two locations in 2005. Variety release dates for the conventionals ranged from 1936 to 1995 and the transgenics from 1996 to 2003 (Table 1). Planting dates ranged from April 23 to May 20 in 2004 and April 18 to May 5 in 2005. Within a year all locations were on different soil types. No irrigation was applied in 2004 however, there were two applications (June 23 and 25) in 2005. Insecticides were vigorously applied in both years. There were six replications for yield and three for yield components and fiber traits. All plots were harvested twice with a mechanical plot picker.

Growing conditions were excellent in the 2004 season and resulted in a record high State average of 1024 lbs lint/acre. The 2005 growing season was unusually hot in August with average maximum temperatures of 95.1°. The average maximum August temperature is 90.2° F. This was followed by two strong storms generated by hurricanes Katrina and Rita. State average yields were 854 lbs lint/acre, 17% less than that for 2004. Similarly the average yields in this study were 1403 lbs lint/acre in 2004 and 1042 lbs lint/acre in 2005.

One purpose of this study was to determine what contribution to yield increase was due to transgenic varieties. The average yield of seventeen conventional and twelve transgenic varieties plotted against their year of release is shown in Figure 5. The regression of yield for conventional varieties released from 1936 to 1995 shows an annual increase in yield due to varietal improvement of 6.5 lbs lint/acre. This is very similar to the 6.2 lbs lint/acre/year given in Figure 1. However, little improvement in yield is evident after 1995.

The yield, yield components, and HVI fiber traits of a sub-set of the obsolete varieties released from 1974 to 1995 is shown in Table 1. The average variety release date was 1985 for conventional varieties and 2000 for transgenics. Average yield for conventional and transgenic varieties was 1321 and 1325 lbs lint/acre, respectively. The fiber properties also offer little difference for the two types of varieties. Since State average yield has been high the last two years, a more appropriate comparison would be to compare the most used transgenic varieties grown in 2004 and 2005 with high-performing obsolete varieties. The Agricultural Marketing Service's annual listings (2004-2005) for the transgenics show that DP 555BR, DP 444BR, PM 1218BR, ST 4892BR and ST 5599BR account for at least 76% of the Midsouth and Mississippi acreage. The average conventional acreage planted for Mississippi was 0.51% and 2.38% for the 2004 and 2005 seasons, respectively. The average variety release date for conventional and transgenic varieties was 1987 and 2002, respectively. Their average yields were 1393 and 1365 lbs lint/acre, respectively. As expected when using the backcross breeding method, none of the comparison methods of obsolete and conventional varieties show any increase in yield or fiber quality due to transgenics.

The backcross method is well documented as an efficient breeding method for adding single genes to an established variety. However, the assumption is to, at best, maintain about the same yield and fiber quality as that for the established variety. This expectation is that the introduced gene has no deleterious physiological effects on yield and fiber quality. It is now well established that this assumption is not valid for all variety backgrounds. A more efficient method of using transgenics is to incorporate them early

into a forward conventional breeding program as well as using the backcross method. If backcrossing into old obsolete varieties continues, we cannot expect yields and fiber quality to improve above the performance of the old varieties. The average breeding time to produce a new variety using the conventional method is eight to ten years. The average time to convert this new variety into a transgenic is five years. If the regulatory life of a pesticide induced transgene is 13 to 15 years, little time is available for conventional breeders to produce a marketable variety, and this will discourage breeders from using conventional breeding.

The use of transgenics in reducing crop losses due to weeds has been more difficult to estimate. The primary benefit of the transgenic herbicide resistant varieties has been to make management simpler and allow one grower to handle more acres and do it more efficiently than previously.

Another technology change in Mississippi has been the use of more mixed fertilizers than the major dependence on nitrogen alone. Perhaps the technology that has resulted in the most increase in yield is that which results in more rapid harvesting of the crop. The losses due to weathering are much less than they were 20 years ago. Other technology improvements are in crop management and ginning.

The almost complete use of the backcross breeding method to produce added value traits accounted for 82.6% of the US acreage and 97.6% of the Mississippi acreage in 2005. It has indirectly through control of major pests resulted in about a 2% increase in yield. However, the major increase in yields in the last five years has been due almost entirely on other technologies. Also there's been little positive change in improving fiber quality. The lack of genetic progress is not due to the transgenes *per se*, but to the breeding method being used.

### Conclusions

The average Mississippi yields for the years 2001 to 2005 (USDA-Crop Reporting Service, 2001 – 2005) is 871 lbs lint/acre. This is 20% higher than the average yield of 724 lbs lint/acre for the 1986 to 1995 pre-transgenic period (USDA-Crop Reporting Service, 1986 – 1995). The average yield for the transitional period of 1996 – 2000 which involved both conventional and transgenic varieties was 761 lbs lint/acre.

The objective of this study was primarily to estimate the impact varietal improvement has had on yield and fiber quality, with special emphasis on the effect of transgenic varieties. Estimating the specific effects of other technologies is beyond the scope of this research and it is difficult to attribute specific effects to individual technologies when they are all changing at the same time.

However, it is well known that transgenic Bt has had a major impact on the worm complex. Average crop losses due to all insects has decreased from 10.7% for the 1986 – 1995 period to 7.0% for 2001 to 2004 period (Cotton Insect Research Conferences, 1986 – 2004). The

losses were due to decreases due to both the boll weevil eradication program of 2.1% to 0.0% from the respective periods and losses due to the worm complex of 5.0% to 3.0% for the respective before and after Bt periods.

There are limits as to what other non-genetic technology improvements can do to increase yields. Foreign competition is using the same transgenes as US breeders but they are not bound to the absolute use of the backcross method. If this continues, ultimately the foreign breeders will be more efficient in producing increased yields and the type fiber quality needed for their textile mills.

Have we learned that great changes can occur in 10 years?

### **References**

USDA-AMS 1936 – 2005. Cotton varieties planted.

Cotton Insect Research and Control Conference. Proceedings of the Beltwide Cotton Production Conferences. National Cotton Council of America, Memphis, TN.

Table 1. Average yield, yield component, and fiber properties of obsolete conventional varieties and modern transgenic varieties grown in 2004 & 2005.

<b>Obsolete</b>										
<b>Variety</b>	<b>Year of</b>	<b>% of 1<sup>st</sup></b>	<b>Lint yield</b>	<b>Lint</b>	<b>Boll Wt</b>	<b>Seed wt</b>	<b>Staple length</b>	<b>Uniformity</b>	<b>HVI</b>	
<b>1936 - 1965</b>	<b>Release</b>	<b>Pick</b>	<b>lbs/ac</b>	<b>%</b>	<b>g</b>	<b>mg</b>	<b>Inches</b>	<b>Index</b>	<b>strength</b>	<b>Micronaire</b>
DP 11	36	90.7	1017	39.0	5.09	10.1	1.133	84.0	29.0	4.67
ST 28	38	85.5	1056	35.0	5.45	10.5	1.165	84.2	30.7	4.57
ST 5A	38	90.6	989	35.8	5.41	10.7	1.145	83.9	30.5	4.67
DP 14	41	93.9	1039	36.5	4.86	9.9	1.133	83.2	28.8	4.46
DP 15	47	93.2	1039	37.1	5.17	9.8	1.139	83.7	29.7	4.51
DP SmLF	59	92.3	1161	37.3	5.31	10.3	1.143	84.1	29.7	4.52
ST 213	62	92.0	1215	37.6	5.24	9.5	1.145	84.0	30.1	4.76
DP 16	65	91.9	1219	38.0	5.02	10.1	1.153	83.8	29.9	4.58
<b>AVERAGE</b>	<b>48.2</b>	<b>91.3</b>	<b>1092</b>	<b>37.0</b>	<b>5.19</b>	<b>10.1</b>	<b>1.144</b>	<b>83.9</b>	<b>29.8</b>	<b>4.59</b>

<b>Obsolete</b>										
<b>Variety</b>	<b>Year of</b>	<b>% of 1<sup>st</sup></b>	<b>Lint yield</b>	<b>Lint</b>	<b>Boll Wt</b>	<b>Seed wt</b>	<b>Staple length</b>	<b>Uniformity</b>	<b>HVI</b>	
<b>1974 - 1995</b>	<b>Release</b>	<b>Pick</b>	<b>lbs/ac</b>	<b>%</b>	<b>g</b>	<b>mg</b>	<b>Inches</b>	<b>Index</b>	<b>strength</b>	<b>Micronaire</b>
DPL 61	74	89.4	1276	37.4	5.58	10.7	1.175	84.8	30.6	4.73
DPL 41	76	93.5	1404	41.6	4.93	9.7	1.157	83.9	30.3	4.65
ST 825N	78	94.4	1301	38.4	5.08	9.9	1.171	84.1	29.6	4.69
ST 506	81	94.5	1184	36.8	5.05	10.8	1.138	83.6	29.2	4.61
DP 50	84	95.1	1175	36.5	5.16	10.3	1.158	84.2	28.8	4.63
ST 453	88	93.9	1288	38.4	5.07	10.3	1.168	84.2	28.6	4.52
DP 5415	91	91.2	1251	40.1	4.67	9.2	1.151	84.2	30.3	4.84
ST 474	95	95.4	1497	42.3	4.58	10.0	1.154	84.3	30.3	4.69
SG 125	95	93.1	1512	40.8	5.11	10.2	1.154	84.7	30.3	4.82
<b>AVERAGE</b>	<b>84.7</b>	<b>93.4</b>	<b>1321</b>	<b>39.1</b>	<b>5.03</b>	<b>10.1</b>	<b>1.158</b>	<b>84.2</b>	<b>29.8</b>	<b>4.68</b>

Table 1. Continued.

<b>Transgenic Variety 1996 - 2003</b>	<b>Year of Release</b>	<b>% of 1<sup>st</sup> Pick</b>	<b>Lint yield lbs/ac</b>	<b>Lint %</b>	<b>Boll Wt g</b>	<b>Seed wt mg</b>	<b>Staple length Inches</b>	<b>Uniformity Index</b>	<b>HVI strength</b>	<b>Micronaire</b>
DP 33B	96	93.2	1296	38.2	4.75	9.5	1.156	84.2	29.9	4.67
DP 5415R	97	91.9	1324	40.5	4.73	9.4	1.155	84.1	30.0	4.67
ST BXN47	97	95.0	1403	41.9	4.53	9.9	1.147	84.1	30.6	4.60
DP 458BR	98	91.9	1269	39.2	4.69	9.5	1.148	83.9	31.2	4.80
DP 436R	98	94.6	1137	36.1	5.04	10.3	1.163	84.2	29.1	4.64
DP 451BR	99	90.8	1202	36.4	4.94	10.2	1.138	83.8	28.8	4.62
PM 1218BR	99	95.4	1364	39.0	5.29	10.1	1.122	84.1	28.4	4.68
SG 521R	101	92.0	1424	39.7	5.05	10.3	1.137	84.3	30.4	4.70
ST 4892BR	101	94.2	1398	40.5	4.82	10.2	1.146	84.4	30.4	4.63
DP 555BR	102	87.6	1304	43.6	4.63	9.1	1.155	83.7	29.3	4.73
ST 5599BR	103	91.5	1406	39.4	5.75	10.9	1.147	83.9	30.4	4.76
DP 444BR	103	95.5	1353	41.0	4.91	10.2	1.151	84.3	30.4	4.59
AVERAGE	99.5	92.8	1323	39.6	4.93	10.0	1.147	84.1	29.9	4.67
LSD 0.05*	--	0.4	58	1.2	0.18	0.6	0.019	0.6	1.4	0.19

\*LSD is valid for comparing any of the 29 varieties listed.

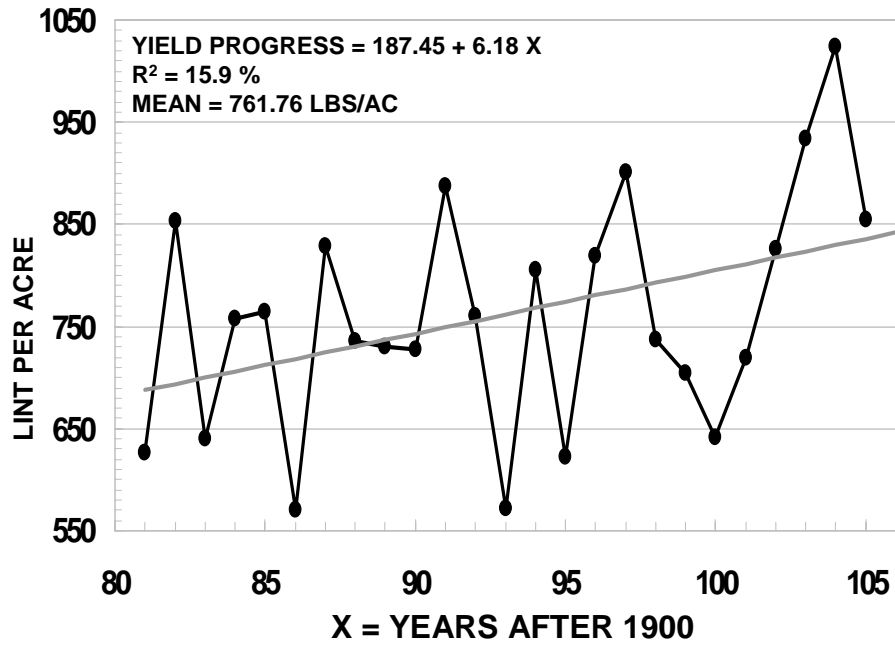


Figure 1. Average Mississippi lint yield for the years 1981 – 2005.

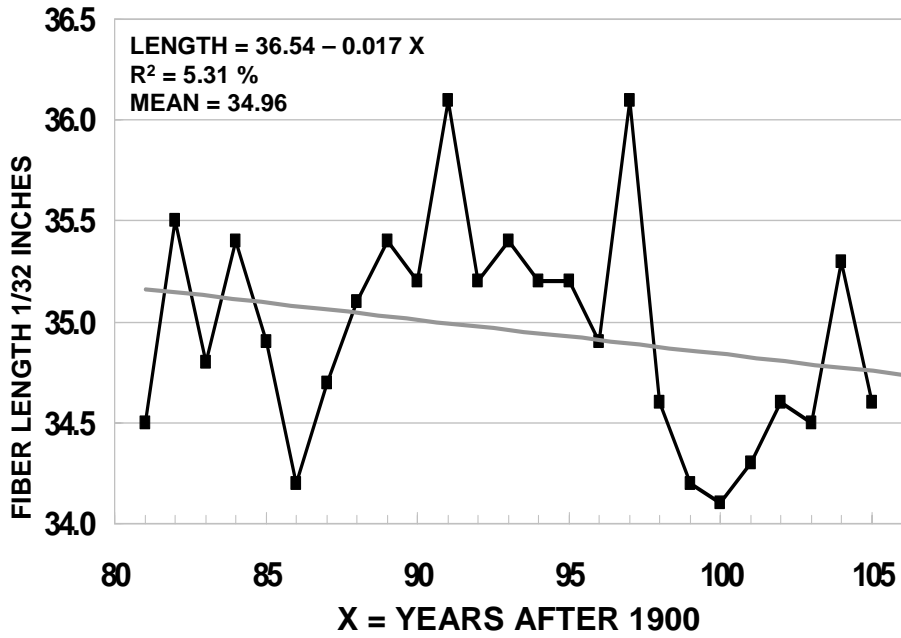


Figure 2. Average Mississippi fiber length for the years 1981 to 2005.

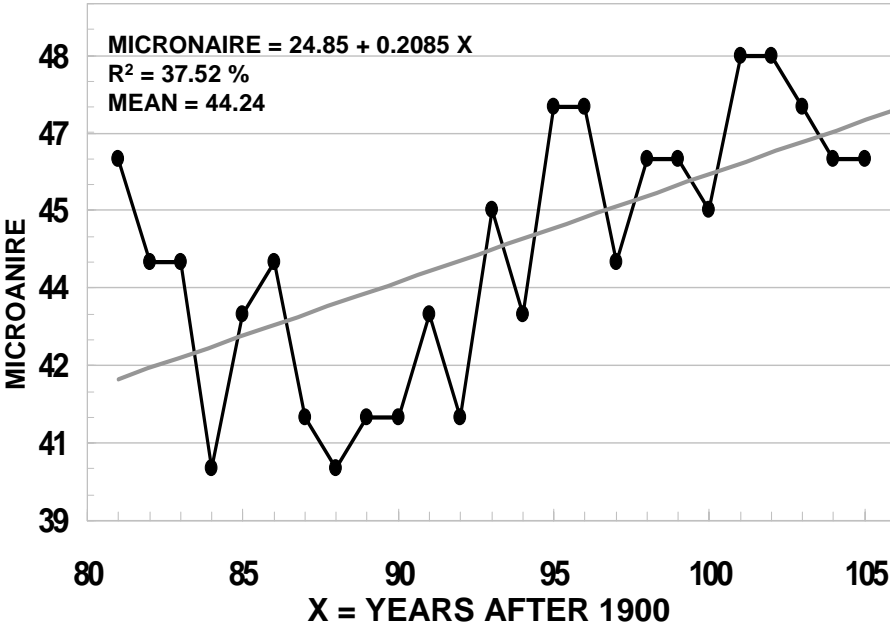


Figure 3. Average Mississippi micronaire for the years 1981 to 2005.

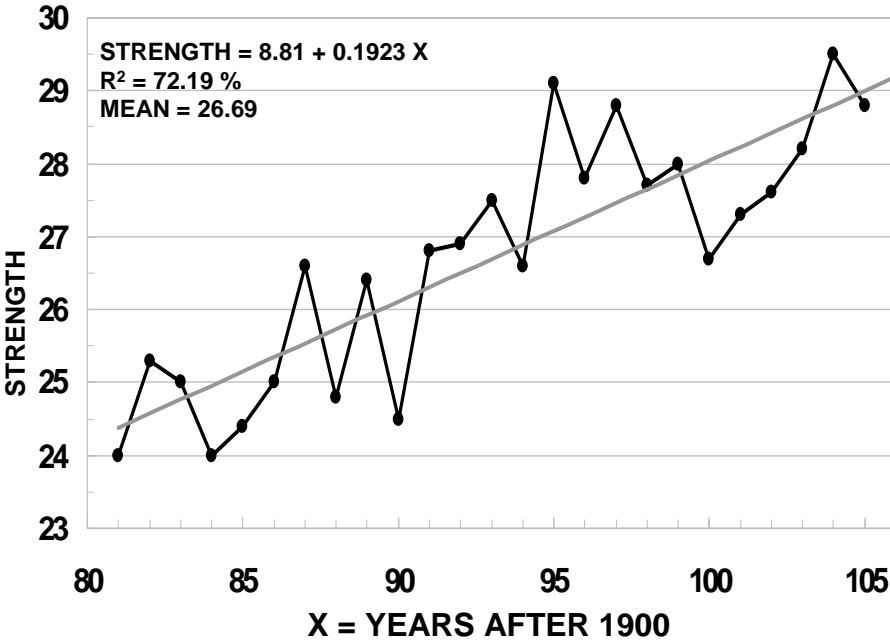


Figure 4. Average Mississippi HVI strength for the years 1981 to 2005.

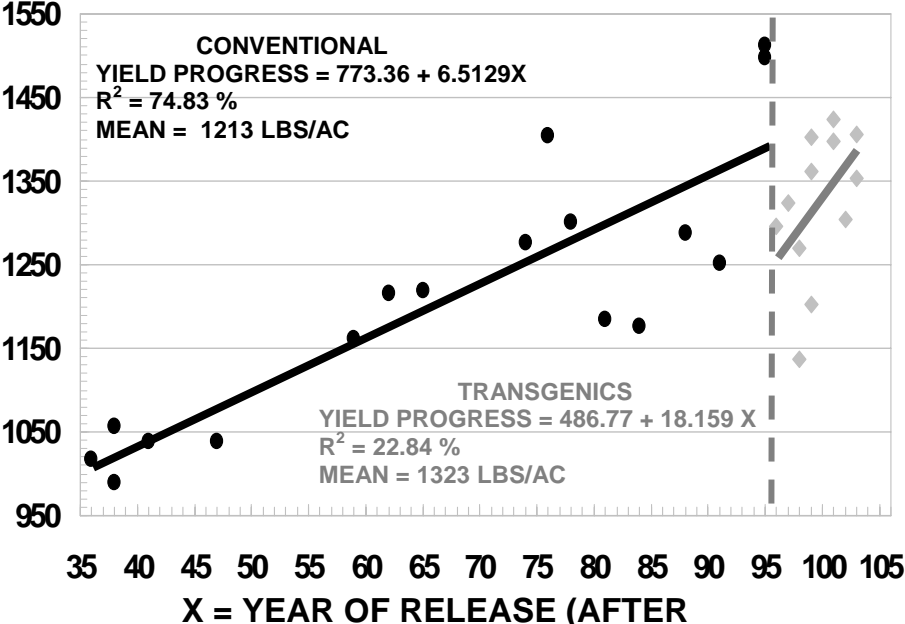


Figure 5. Average lint yield (lbs/ac) for release years of conventional (1936 – 1995) and transgenic (1996 – 2003) varieties.