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Deltapine Variety Yield and Fiber Quality Improvements in the US from the pre-transgenic era (1980's) to 3rd generation traited varieties (2018-2019)

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DELTAPINE® VARIETY YIELD AND FIBRE QUALITY IMPROVEMENTS IN THE U.S. FROM THE PRE-TRANSGENIC ERA (1980'S) TO 3RD GENERATION TRAITED VARIETIES (2018-2019)

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ABSTRACT

Cotton spinners are demanding improvements in fibre length related properties according to a 2018 survey. Fibre quality of the U.S. cotton crop has shown recent improvements in fibre length, with smaller improvements in fibre strength, according to USDA- AMS summaries. An analysis of over 11,000 variety test locations conducted by Delta and Pine Land Company, followed by Monsanto and Bayer from 1994 to 2019 determined the relative slopes of yield and fibre quality parameters over that period. The recent Deltapine® variety classes have shown significant improvements for fibre length (2016) and fibre strength (2018), while also showing a strong yield improvement, particularly in the 2016 released varieties. The slopes of lint yield and fibre length improved significantly in 1996 and 2009, respectively. The lint yield slope change occurred at the beginning of the transgenic era, and the fibre length slope improvement was later after the end of the Delta & Pine Land era. The long-term yield trend analysis also revealed 3 step-changes in yield since 2000 for varieties released in 2003, 2009, and 2016. Only the class of 2016 varieties also had fibre lengths above the trend line, showing that this recent class of Deltapine releases was unique in bringing lint yield improvement and fibre length improvement together for the U.S. cotton grower.

INTRODUCTION

Cotton fibre quality trends for the U.S. cotton crop (from 1980 to 2019) have shown recent improvements in fibre length and fibre strength, while micronaire and uniformity index have been relatively flat trend lines in recent years based on USDA-AMS annual summaries (Figure 1). These overall fibre quality trends and the recent improvements in fibre length, line up with the report of Drelig, et al. (2018) where length-related properties were the top response of spinners for improvements needed in cotton characteristics. The long-term U.S. crop trends show the highest R-squared fit of the quadratic functions for fibre strength (0.93) and fibre length (0.78), compared to micronaire (0.38) and uniformity index (0.36). One hypothesis of these comparative trends would be that the seed companies and growers have been much more focused on improving fibre length and strength, or that the environment interactions are causing more year to year variation for a variable like micronaire. These overall fibre quality parameters are provided as background for the discussion of Deltapine fibre quality trends.

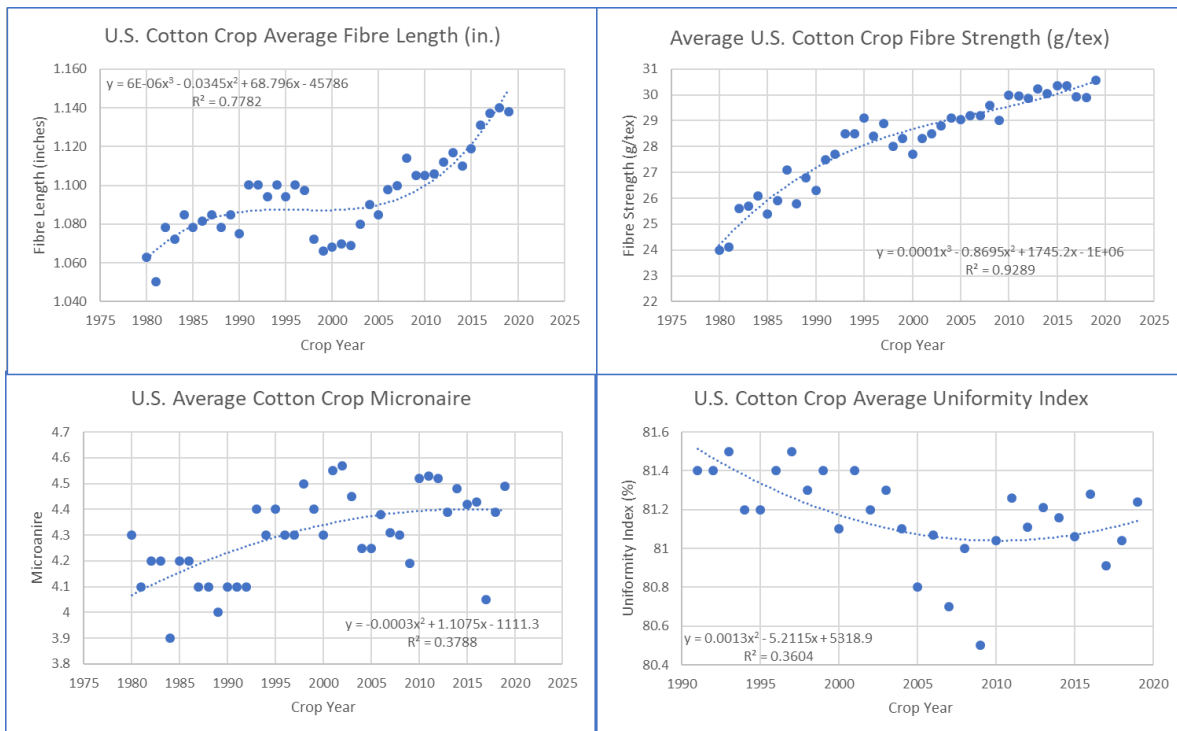


Figure 1. U.S. Cotton Crop Average Fibre properties (length, strength, micronaire, length uniformity) from 1980 to 2019. Source: USDA-AMS Annual Reports.

Previous reports from Kerby and Hugie (2006 and 2007) and Kerby (2006) have discussed the relationships between fibre quality and yield in varieties released by Delta & Pine Land Company from 1980 to 2006. One change that they noted was that the association of increased micronaire to improve yield in varieties released prior to the 2000 growing season. The relationship of yield and micronaire was not noted in the varieties released between 2000 and 2005. In the same report, they noted a modest negative association between fibre length and yield; and between fibre strength and yield. In another report (Kerby and Hugie, 2006), they showed that the most recent 5-year period (2001 to 2005) had the greatest yield improvement (15 lb / acre / year) over the previous period, while during the 2 earliest periods (1981 to 1995) the yield improvement had been just above 3 lb / acre / year. During the period from 1989 to 2000 they reported modest decline in fibre length and strength; but in the later period (ending in 2005) they reported small increases in fibre length and strength and reduction in micronaire.

The purpose of this report is to update the long-term view of Deltapine yield and fibre quality compared to the varieties released recently (2016 to 2018), along with preliminary reports on the 2019 and 2020 released varieties.

METHODOLOGY

An archive of internal and external public cotton variety trials that began in 1994 by Delta & Pine Land Company and continued through 2019 (by Monsanto and Bayer)

was analysed for trends in cotton yield and fibre quality by variety year of release group. The year of release of varieties included range from 1980 to 2020. A total of over 11,000 field trials were analysed by ANOVA that generated Least Square Means for lint yield, lint percent, fibre length, fibre strength, micronaire, and uniformity index.

Varieties included in this study are Deltapine® brand and the associated brands of Sure-Grow®, Paymaster®, and Hartz Cotton® purchased by Delta & Pine Land Company in the 1990's. Monsanto Company acquired Delta & Pine Land Co. in 2007 and continued releasing new cotton varieties in the Deltapine brand. Bayer acquired Monsanto in 2018 and has also continued the Deltapine cotton brand with releases of new cotton varieties in 2019 and 2020. Over this time frame, cotton varieties released in Deltapine and related brands have transitioned from conventional to Bollgard® (1996), Roundup Ready® (1997), Bollgard II® (2004), Roundup Ready Flex® (2006), XtendFlex® (2015), and Bollgard3® (2018), and stacked trait versions of the insect tolerant and herbicide tolerant traits.

LINT YIELD AND FIBRE QUALITY TRENDS

The slope of the linear trend for yield is just under 7 lb / acre / year for the 40 years of Deltapine variety release from 1980 to 2020 (Figure 2). The top graph shows the long-term linear trend line, while the bottom graph has two trend lines: one from 1980 to 1995 (pre-transgenic era) and a second trend-line from 1996 to 2020 (transgenic era). The slope in the pre-transgenic era is 3.2 lb. / acre / year, similar to the report from Kerby and Hugie (2006) during the early pre-transgenic years in their analysis. The slope in Figure 2 (bottom graph) in the post-transgenic era (releases from 1996 to 2020) increases to over 8 lb / acre / year.

Figure 2 also illustrates 3 yield “step changes” since 2000 in the Deltapine releases: in 2003 with the release of DP 555 BG/RR, in 2009 with the release of DP 0912 B2RF, and 2016 with the release of DP 1646 B2XF (marked with arrows ↓ on the top graph). While all three of these varieties became widely planted varieties, only the 2016 released DP 1646 B2XF had both a yield step and a fibre quality (length) increase. The 2003 and 2009 classes had fibre lengths that were significantly below the trend lines showing the trade-off in those classes for yield step increases that came at the cost of fibre quality decreases. With that perspective, DP 1646 B2XF (in the 2016 release group) is truly unique in Deltapine releases to bring improved fibre length and lint yield (step change) in the same variety. This combination of yield and quality is a major driver in the large market share of DP 1646 B2XF in the U.S. Cotton Belt. According the USDA-AMS varieties planted report for 2019, DP 1646 B2XF was the top-planted variety in the U.S. for the 3rd consecutive year with 22.5%; which is 6 times the 2nd most planted variety. DP 1646 B2XF was planted on the largest percentage of the U.S. cotton acres in 2018 and 2019 since Deltapine 16 was planted on 23% of the U.S. cotton acres in 1973 (USDA-AMS archives).

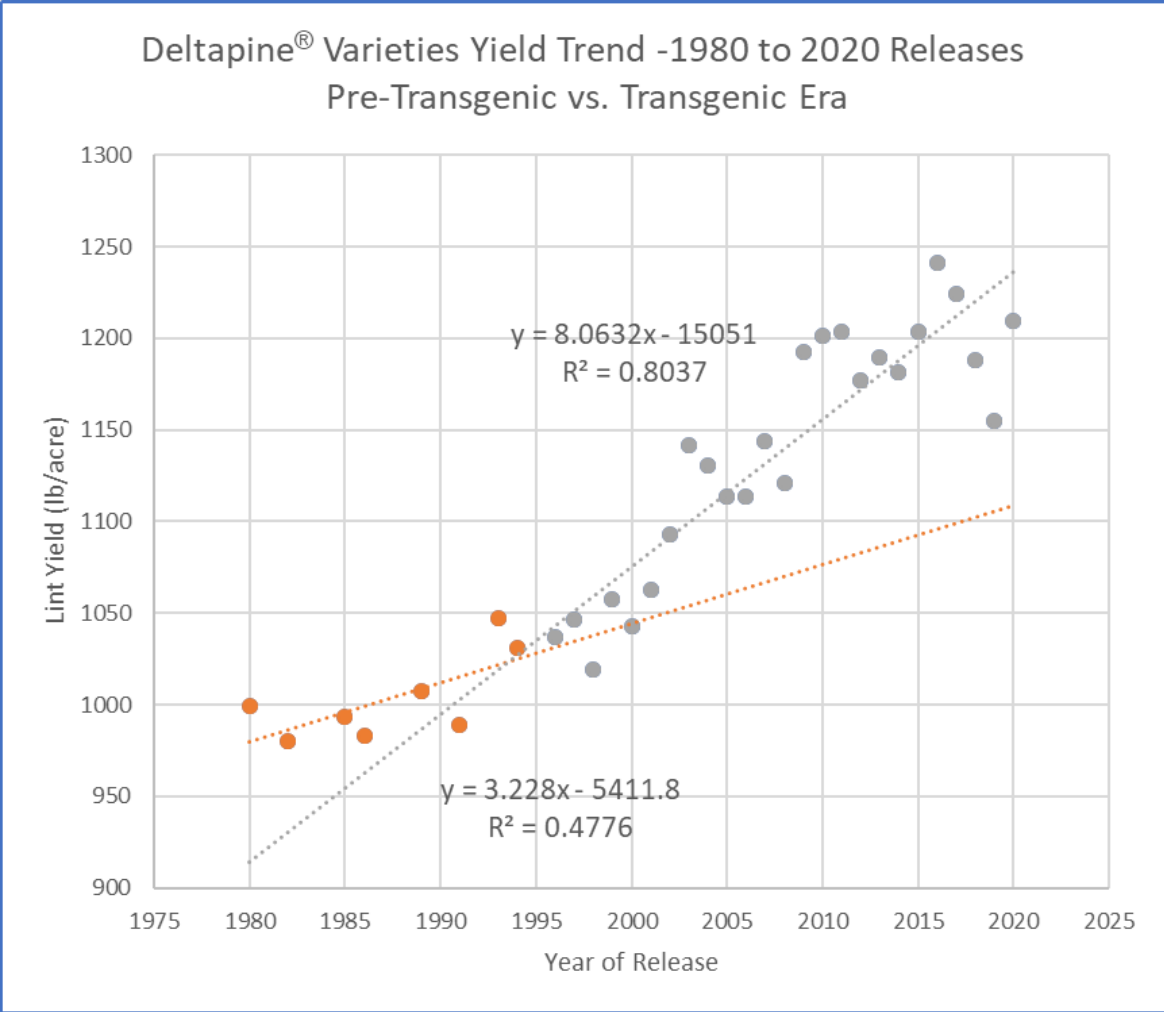
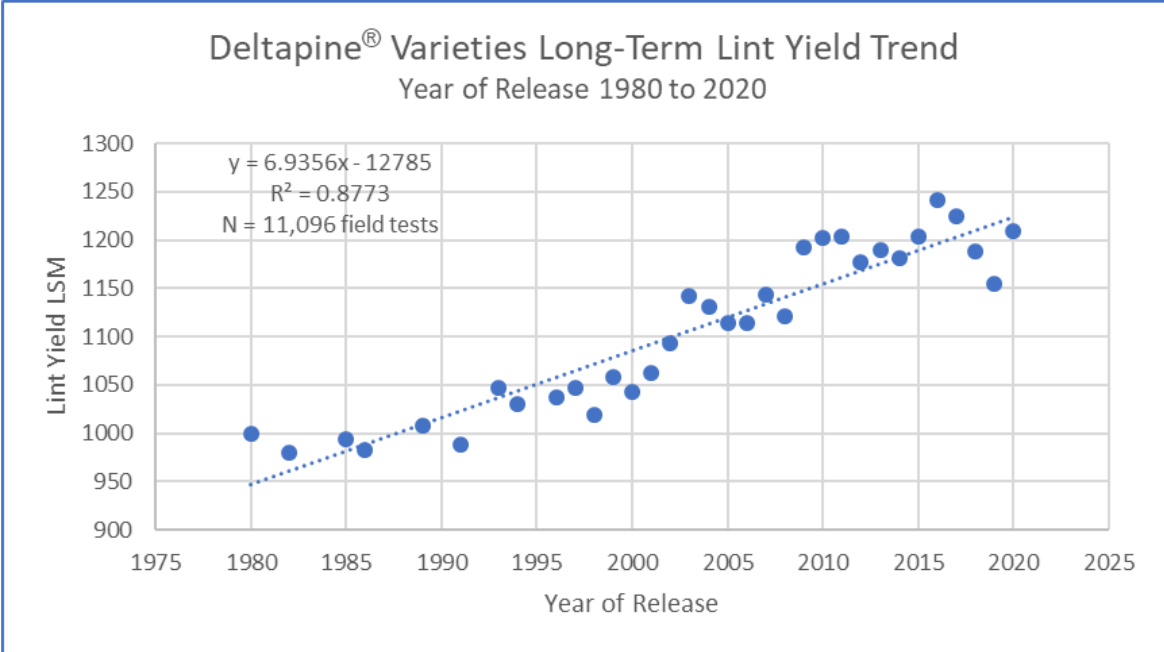


Figure 2. Deltapine Long-Term Lint Yield Trend for Year of Release 1980 to 2020

Figure 3 illustrates the fibre length trend for the Deltapine varieties released from 1980 to 2020. The top graph shows the polynomial fit of the trend line, while the bottom graph shows the fibre length trend broken into 2 eras or periods: Delta & Pine Land (D&PL) era and the Monsanto / Bayer era (first class of new releases in 2009). While the shift in yield gain (slope) seen in Figure 2 began in 1996 with the “transgenic era”, the shift in fibre quality was several years later. The slope of the fibre length trend line in the earlier D&PL era (1980 to 2008) is 0.001 inches / year vs. 0.0045 inches / year in the 2009 to 2020 window. While the exact causation of the increased fibre length is not within this analysis, several factors likely contributed: including selection intensity for fibre length, larger pipeline of candidates, and improved tools for managing the Deltapine breeding pipeline and selections. While the recent classes of 2016, 2018, and 2019 have a class average fibre length of ~1.17 inches, the longest fibre length varieties in these classes range from 1.20 to 1.24 inches.

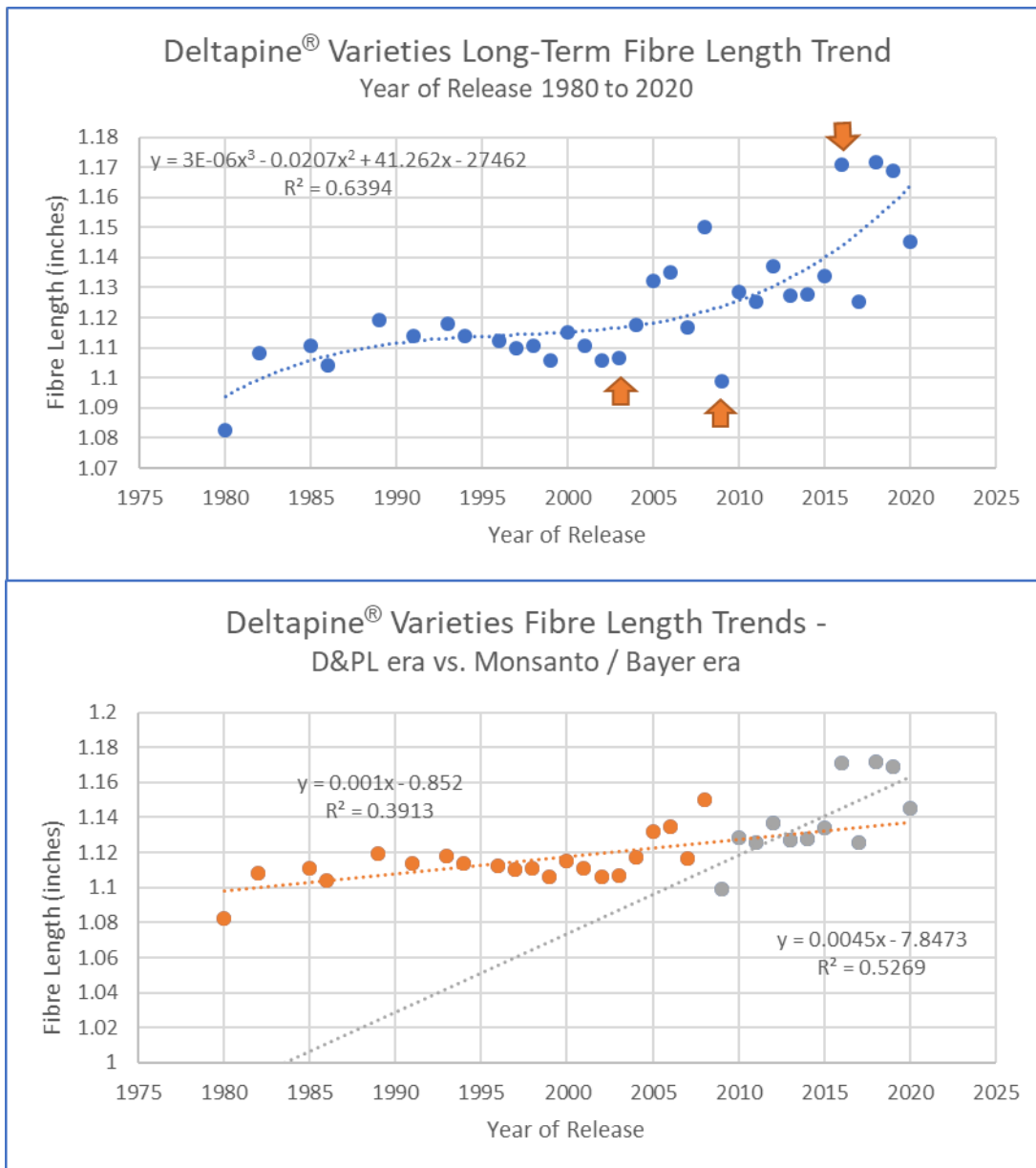


Figure 3. Deltapine Long-Term Fibre Length Trend for Year of Release 1980 to 2020

Figure 4 summarizes the remaining fibre quality data and the lint percent data for Deltapine releases from 1980 to 2020. The highest R-squared for any of these trend lines is for lint percent (0.87), which has been a yield component used to increase lint yield, as reported by Kerby and Hugie (2007). The micronaire trend has been negative (reducing micronaire) in recently released classes, although the R-squared for this trend line is lowest of these 4 factors, at 0.197. The fibre strength and uniformity index have similar R-squared values at 0.26 and 0.24, respectively. Both factors have shown small, but noticeable improvements in recent release classes;

e.g. the Deltapine release classes of 2018 and 2019 had average fibre strengths above 31 g/tex.

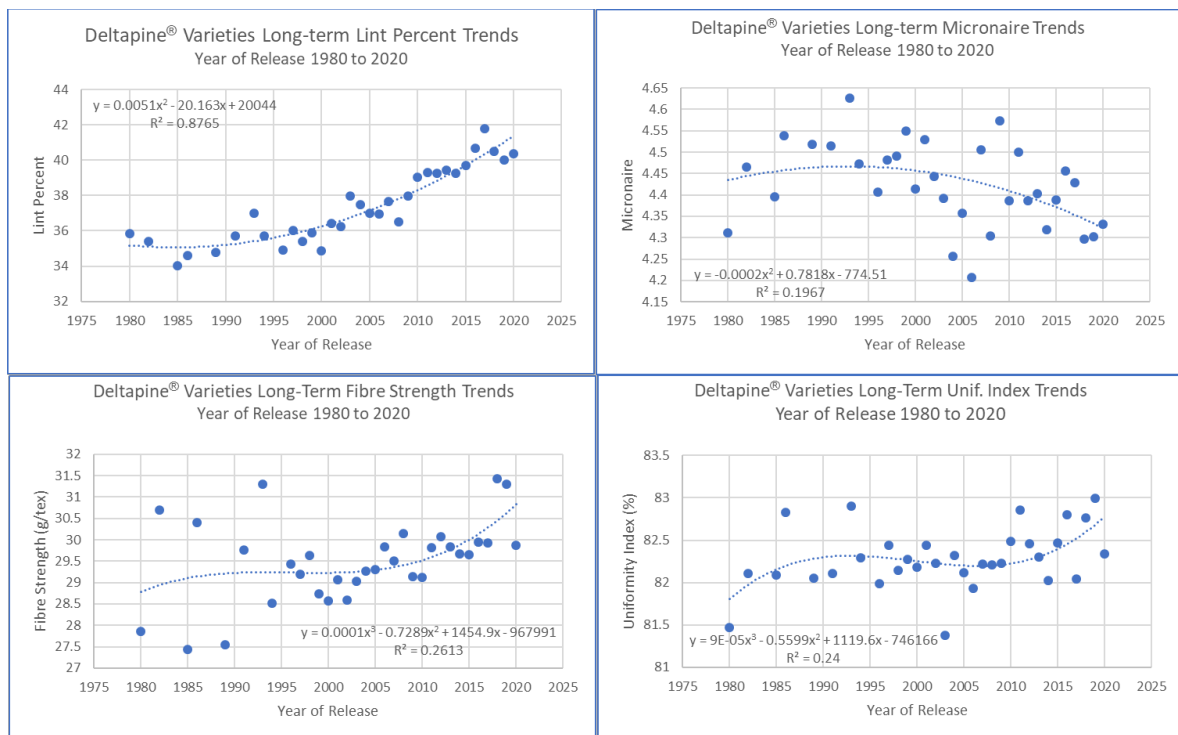


Figure 4. Deltapine Long-Term Lint Percent, Micronaire, Fibre Strength, and Uniformity Index Trends for Year of Release 1980 to 2020.

The R-squared statistics are ranked from highest to lowest in Table 1. Lint yield and lint percent have the highest R-squared stats, followed by fibre length, fibre strength, uniformity index, and micronaire. Cotton breeding selection criteria rankings likely mirror the R-squared ranking in Table 1. Regional rankings of these R-squared statistics were similar, but micronaire was ranked higher than Uniformity Index (data not shown).

Table 1. Long Term trendline R-squared for lint yield and fibre quality by Year of Release, 1980 to 2020.

Factor (LSM's)	Beltwide R-squared (Year of Release)
Lint Yield	0.87
Lint Percent	0.87
Fibre Length	0.64
Fibre Strength	0.26
Unif. Index	0.24
Micronaire	0.20

SUMMARY

Long-term trend analysis of Deltapine varieties released from 1980 to 2020 showed that the slope of lint yield and fibre length improved during the study period. The yield slope changed from 3 lb / acre / year to 8 lb / acre / year in 1996 (the beginning of the “transgenic era”. The fibre length slope improved in 2009 (the end of the D&PL era) when the fibre length slope increased from 0.001 inches / year to 0.0045 inches / year. The analysis also revealed that recent release Deltapine classes (2016 and 2018) were unique in that both classes had a yield step-change and fibre length significantly above the trend-line. One of the Deltapine Class of 16 varieties (DP 1646 B2XF) is the top planted variety in the U.S. since 2017, which has exceptional upland fibre length of 1.22 inches.

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