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YIELD STABILITY OF VARIETIES GROWN UNDER DIFFERENT CULTURAL PRACTICES

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Abstract

Yield potential of cotton varieties has long been one of the determining factors to variety selection. Growers have recently begun to look closer at their variety selections to reflect cotton varieties that will perform at a consistent level year in and year out. Stability regression analysis of varieties performance over several years can give a very strong indication of how a variety will withstand variations in growing conditions. Two environmental regimes were separated for comparison purposes. Varieties were evaluated in an irrigated and non-irrigated comparison as well as in a conventional versus reduced-tillage system. A comparison was made for four Delta and Pine Land Company varieties commonly grown in the northern Mid-South Delta region. Linear regression equations were calculated for PM 1218 BG/RR, DP 451 B/RR, DP 436 RR, and Sure-Grow 747. The R^2 value was used to describe the scatter in a variety yield compared to the mean of all varieties from low to high yield environments. High R^2 indicates low variation from the average response of all varieties across environments. DP 451 B/RR and DP 436 RR had the least amount of variation from the trial mean with respect to yield, fiber length, fiber strength, and micronaire. These varieties were determined to be the most stable under normal cotton growing conditions with very little difference from the trial mean. Sure-Grow 747 has a higher yield potential, and also had high R^2- values, slightly lower than DP 436 RR and DP 451 B/RR in the irrigated and conventional tillage comparison. The R^2 of PM 1218 BG/RR for yield appeared to be lower than the other varieties, however, PM 1218 BG/RR has higher yield potential as indicated by a greater slope in irrigated and conventional tillage tests. Risk-averse growers should tend to want more acreage planted to a variety such as DP 451 B/RR, where as high input growers that set a goal for maximum yield might plant more high yielding varieties such as PM 1218 BG/RR.

Introduction

Cotton production in the United States can encompass many different environmental factors. Geographical regions tend to dictate the production practices. Environmental variations within a given production region may cause cotton to respond accordingly (Pustejovsky et al.). Production practices vary from grower to grower, causing even more variation in a given production environment. In the North Delta region of the Cotton Belt, irrigation has become a valuable asset. Irrigation has been shown to boost cotton yields and alter fiber properties (Pringle et al.). Non-irrigated cotton production can necessitate a completely different management scheme for that environment. The differences between cotton production management on irrigated versus non-irrigated can be a challenge for even the most advanced cotton producer.

The potential interactions between a cotton variety planted and differing environmental condition have been well documented (Kerby et al. 2000, Kerby et al. 1996). Conservation tillage has been shown to provide positive benefits to cotton production (McConnell and Kirst, 1999). Economic benefits can provide an increase in net return per acre, while agronomic benefits may be more aligned with increased productivity over a longer than one season period. As cotton growers increase acreage to take advantage of benefits of larger scale operations, many have found that one strong advantage to conservation tillage is the ability to cover more acres at planting with less equipment. Conventional tillage practices have the advantage of the soil temperature rising to an optimum range earlier in the calendar year, as compared with a conservation tillage seedbed. By contrast, the conservation tillage system can be associated with a greater water holding capacity. The differences between the tillage practices represent unique environmental conditions. Variations between growing seasons from year to year has accounted for some differences between tillage systems (Albers et al., McGowen and Wallace).

One of the primary decisions when planning a cotton production year is the determination of the cotton variety. More growers have started to choose cotton varieties not only on the yield potential merits, but on the adaptability and stability of a variety to wide environmental ranges by assessing a varieties performance in a number of local and statewide tests from the state university system. Larger acreage can encompass dramatic differences in environmental parameters. The stability of a variety in this manuscript is defined by R^2 with a high value indicating greater relative stability. The intent of this data analysis has been to determine the stability of selected cotton varieties to the differences between cotton production environments of the North Delta region.

Materials and Methods

Data collection by Delta & Pine Land Company (DPL) is kept in an Oracle database termed the Agronomic Information System (AIS). This database can be queried using various tools. The extent of data entered in the AIS database includes DPL on-farm trials as well as University official variety trials (OVT). Data for this report were selected from the AIS database by variety and geographical region to represent the northern Mid-South Delta cotton growing region. This North Delta data set was further segregated by tillage type and irrigation level. These data subsets were subjected to the stability analysis method developed by Eberhart and Russell (1966). This method was also recently used to describe variety stability of current commercial Delta and Pine Land Company varieties (Kerby, et al. 2001). Comparisons are made within a variety by tillage type or within a variety by irrigation level.

A table of the R^2 values for each variety regression was developed to serve as a comparison among environmental regimes. Varieties chosen were DP 451 B/RR, PM 1218 BG/RR, DP 436 RR, and Sure-Grow 747 due to the fact that these were commonly grown in the North Delta over the last 3 to 5 years. Figures were developed to depict varietal response of DP 451 B/RR over both tillage type and irrigation level.

Results

In table 1, R^2 values are shown to be similar across either irrigation or tillage conditions. The R^2 value describes the scatter in the data across locations. Both DP 451 B/RR and DP 436 RR have R^2 values of 0.866 or greater across all environmental regimes. This indicates that these two varieties perform at a consistent level, as compared to the trial mean, irrespective of the environmental conditions. The consistently high R^2 values indicate that DP 451 B/RR and DP 436 RR are very stable varieties. The Sure-Grow 747 variety performance can likewise be considered a stable condition across irrigation or tillage types. Even though the irrigated R^2 values were somewhat more variable than those of DP 451 B/RR or DP 436 RR, the values were greater than 0.85, which does indicate a low level of variation in performance as compared to the mean of all varieties within the trials.

In comparison it can be determined from table 1 that the PM 1218 BG/RR has a varietal response difference in the irrigation regime columns. Much of the North Delta data used in this analysis is collected in the west Tennessee cotton growing region. It can be noted the non-irrigated R^2 valued for PM 1218 BG/RR is greater than 0.92. This tends to indicate a strong level of confidence in the yield stability of PM 1218 BG/RR in non-irrigated conditions, as compared to the trial mean of other varieties tested in the same trial. In contrast, the R^2 value for PM 1218 BG/RR under irrigated conditions is not as high. Across tillage conditions PM 1218 BG/RR has an R-squared of 0.902 or greater. The R^2 value for PM 1218 BG/RR under reduced tillage or conventional tillage indicates that the stability of this variety does not appear to be affected by tillage type.

The data analysis for variety stability across differing cultural practices was focused on two areas of interest. These were irrigated and non-irrigated environments or conventional and reduced tillage regimes. The first series of graphs will investigate the irrigated and non-irrigated environments. To further expand this analysis, stability regression equations were developed for DP 451 B/RR.

Irrigation Regimes

The yield stability of DP 451 B/RR appears better for non-irrigated conditions than irrigated (Figure 1). In non-irrigated environments, the R^2 is higher than for the irrigated conditions. Additionally, the non-irrigated yield regression line of DP 451B/RR is very similar to the trial mean with an intercept near 0 and slope near 1 (0.98). In other words, the yield response of DP 451 B/RR across varying non-irrigated yield environments is very similar to the trial mean. For irrigated conditions the response of DP 451B/RR across the yield environments is different. The intercept is 103 lbs/acre and the slope is 0.87, indicating stronger performance vs. the trial mean at lower yield environments, with relative decreasing performance at the upper yield environments. This analysis would indicate that DP 451 B/RR is best adapted to dryland conditions or irrigated conditions in lower yielding environments.

The stability analysis of fiber properties also shows some differences in fiber properties across varying environments. The fiber length of irrigated DP 451 B/RR has higher R^2 than the non-irrigated, but also has a greater intercept (0.13 inches) and lower slope (Figure 2). This regression line indicates that under irrigated conditions, DP 451B/RR has fiber length greater than trial mean in short fiber environments, moving toward the trial mean at longer fiber environments. In non-irrigated tests, DP 451B/RR has a slightly lower R^2 (0.726), with an intercept slightly greater than 0 (0.04 inches) and a slope on near 1 (0.97). The stability on fiber length (based on R^2) is slightly lower in non-irrigated conditions, with a fiber length response very close to the trial mean across the varying fiber length environments.

The fiber strength R^2 on DP 451 B/RR was greater for irrigated conditions than for dryland (0.75 vs. 0.57) (Figure 3). DP 451 B/RR has slopes greater than 1 for both irrigated (1.04) and non-irrigated (1.02) conditions, but the overall strength was below the trial mean as indicated by the negative intercepts of both irrigated and non-irrigated conditions (-1.9 g/tex and –1.4 g/tex, respectively). The regression lines were very similar for irrigated and non-irrigated tests, as might be expected for fiber strength, which is more greatly influenced by genotype, than by environment. While the R^2 is higher with irrigated conditions, the overall response across the trial means is very similar for the two irrigation regimes.

The micronaire R^2 is greater for non-irrigated conditions (0.86), than for irrigated conditions (0.76) for DP 451 B/RR (Figure 4). The intercepts for both irrigated and non-irrigated are negative, with DP 451 B/RR having an average micronaire less than the trial mean, up to the high micronaire environments. The slope for both irrigated (1.05) and non-irrigated (1.04) conditions is greater than 1. The lower stability (R^2) of the irrigated tests, may have been due to the timing of irrigations varying widely from location to location. An irrigation of a variety test with varieties of different maturities may have encouraged a longer fruiting period in one variety, while in another variety the extra irrigation may have added weight (micronaire) to bolls on a plant already in cutout. Although the irrigated plots of DP 451 B/RR had an average lower micronaire (4.06 vs. 4.24), the irrigated plots had lower R^2, or more scatter to the data.

Tillage Regimes

The two tillage regimes for DP 451 B/RR had similar R^2 (0.92 vs. 0.93) (Figure 5). Under conventional tillage, DP 451 B/RR had a higher intercept and a lower slope, than with reduced tillage. The regression line for reduced tillage was very similar to the trial mean with an intercept just less than 0 (-3 lb/acre) and a slope of almost 1 (0.98). The conventional tillage plots of DP 451 B/RR had an intercept of 69 lb/acre and a slope of 0.9. With conventional tillage, the performance of DP 451 B/RR is strongest with lower yielding environments, while the yield response of DP 451 B/RR with reduced tillage is very stable and near the trial mean across the range of yield environments tested.

The fiber length regressions showed different patterns across the range of trial means (Figure 6). Reduced tillage had a higher R^2 (0.85) than conventional tillage (0.81). With conventional tillage, the fiber length of DP 451 B/RR was longer vs. the trial means in short fiber environments, as noted with an intercept of 0.16 and a slope 0.87. This is similar to the fiber length regression for irrigated tests (Figure 2), which may suggest that the conventional tillage plots have a large representation of irrigated fields. With reduced tillage, the intercept is negative (-0.18 inches) and slope in strongly positive (1.18). With reduced tillage, DP 451 B/RR is very responsive to shorter vs. longer staple environments. Many of the reduced tillage tests in the North Delta are in West Tennessee on dryland fields, where mid season water stresses can have a large impact on final fiber length.

The R^2 of fiber strength of DP 451 B/RR is again relatively lower than the other fiber or yield analysis (Figure 7). The conventional tillage R^2 of 0.73 is greater than the reduced tillage R^2 of 0.71, but both are likely lower than the other fiber R^2 since fiber strength in predominately influenced by genotype, and not environment. The conventional tillage regression had a positive intercept (1.24 g/tex) and a slope less than 1 (0.92), while the reduced tillage regression had a very negative intercept (-6 g/tex) and a strongly positive slope (1.18). The reduced tillage response may be similar to the fiber length response and impacted by mid-season water stresses in non-irrigated, reduced tillage tests.

The stability (R^2) of micronaire was similar for the two tillage systems (0.86 vs. 0.84), however, the regression lines are quite different (Figure 8). The reduced tillage regression line is very similar to the trial means with an intercept near 0 (-0.1) and a slope near 1 (0.99). This regression line would indicate that the DP 451 B/RR in reduced tillage has micronaire response very similar to the trial means, across the range of micronaire values. With conventional tillage, the intercept is negative (-0.7) and the slope is strongly positive (1.15). Conventional tillage DP 451 B/RR had average micronaire higher than the reduced tillage (4.23 vs. 4.06) , with conventional tillage micronaire values moving above the trial means in the high micronaire environments.

Summary

The yield stability (R^2) of the cotton varieties in this study in differing cultural practices in the North Delta ranged from 0.763 to 0.966. In the upper Mid-South Delta, short season cotton varieties in this study with the highest yield stability (R^2) were DP 451 B/RR, DP 436 RR, and Sure-Grow 747. These varieties have shown excellent fit for varying cultural practices. The R^2 of PM 1218 BG/RR for yield appeared to be lower than the other varieties, however, PM 1218 BG/RR has higher yield potential as indicated by a greater slope in irrigated and conventional tillage tests. Although increased yields can be realized with irrigation, the R^2 was slightly lower for irrigated conditions, than non-irrigated conditions. The fiber properties most affected by irrigation were fiber length and micronaire. Tillage practices are another variable across the Upper Delta. In the analysis of stability of these four Delta & Pine Land varieties, tillage had only slight impact on the stability (R^2) of the cotton varieties listed, when regressed over the mean of all varieties tested in these trials. Reduced tillage practices have shown no detrimental effects on the performance of DP 451 B/RR fiber properties and very similar yield potential to conventional tillage. Risk-averse growers should tend to want more acreage planted to a variety such as DP 451 B/RR, where as high input growers that set a goal for maximum yield might plant more high yielding varieties such as PM 1218 BG/RR.

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Table 1. R-squared values for stability regression equations on yield for selected Delta & Pine. Land Company varieties as influenced by environment (1998-2001).

	Irrigation		**Tillage**	
Variety	**Irrigated**	**Non-irrigated**	**Convention**	**Conservation**
DP 451 B/RR	0.866	0.920	0.924	0.929
	(44)*	(77)	(47)	(47)
PM 1218 BG/RR	0.763	0.921	0.902	0.914
	(35)	(56)	(28)	(40)
DP 436 RR	0.920	0.939	0.946	0.958
	(38)	(54)	(39)	(33)
Sure-Grow 747	0.853	0.962	0.941	0.966
	(31)	(39)	(40)	(12)

*n values in parenthesis

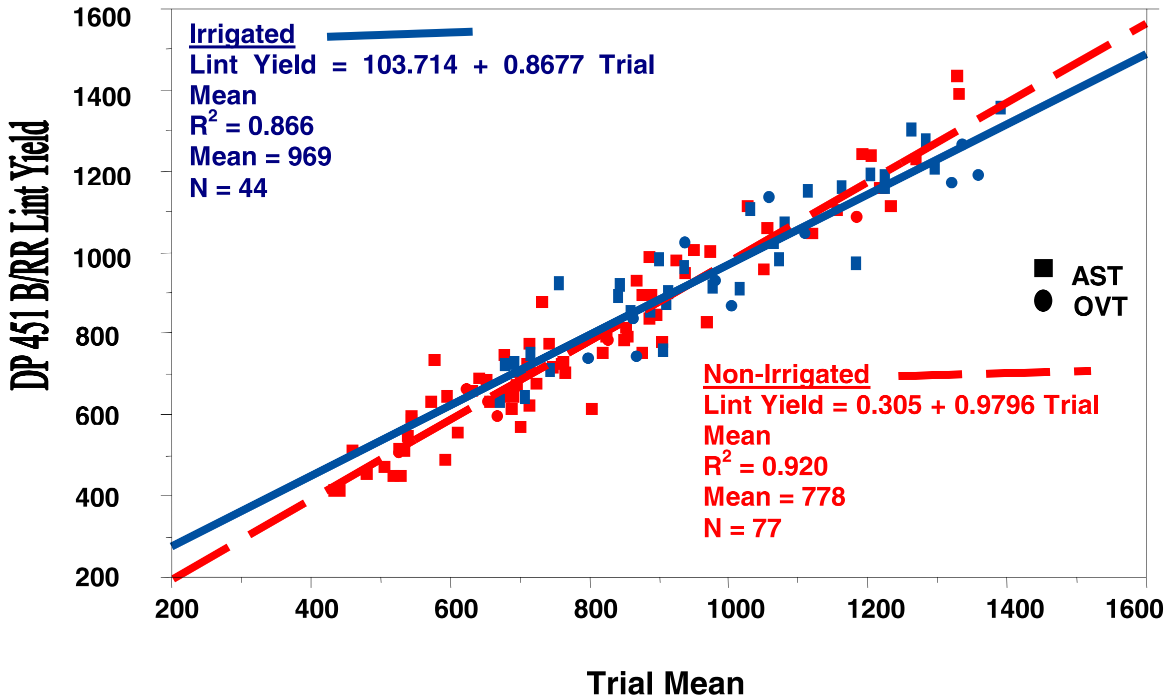

Figure 1. Yield stability lines for DP 451 B/RR under irrigated versus non-irrigated environments regressed against the mean of all varieties in the respective data subset. Irrigated regression line is represented by the solid line, while the non-irrigated regression line is depicted by the dashed line. Data collected from 1998 through December 2001.

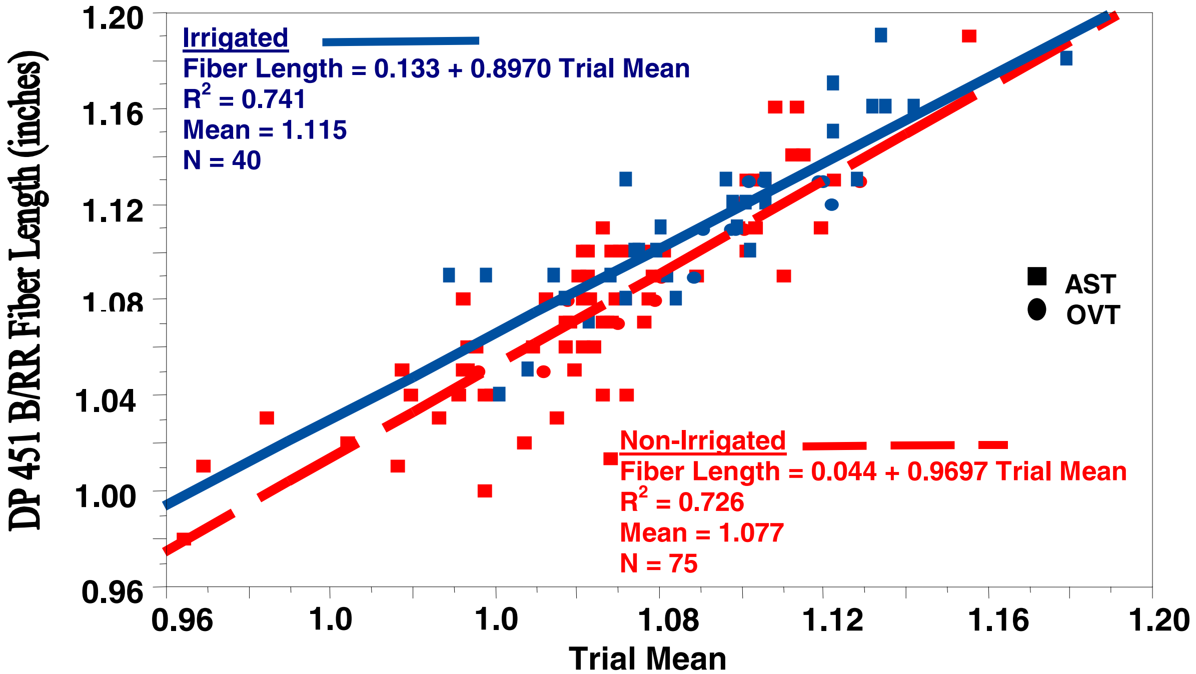

Figure 2. Fiber length stability lines for DP 451 B/RR under irrigated versus non-irrigated environments regressed against the mean of all varieties in the respective data subset. Irrigated regression line is represented by the solid line, while the non-irrigated regression line is depicted by the dashed line. Data collected from 1998 through December 2001.

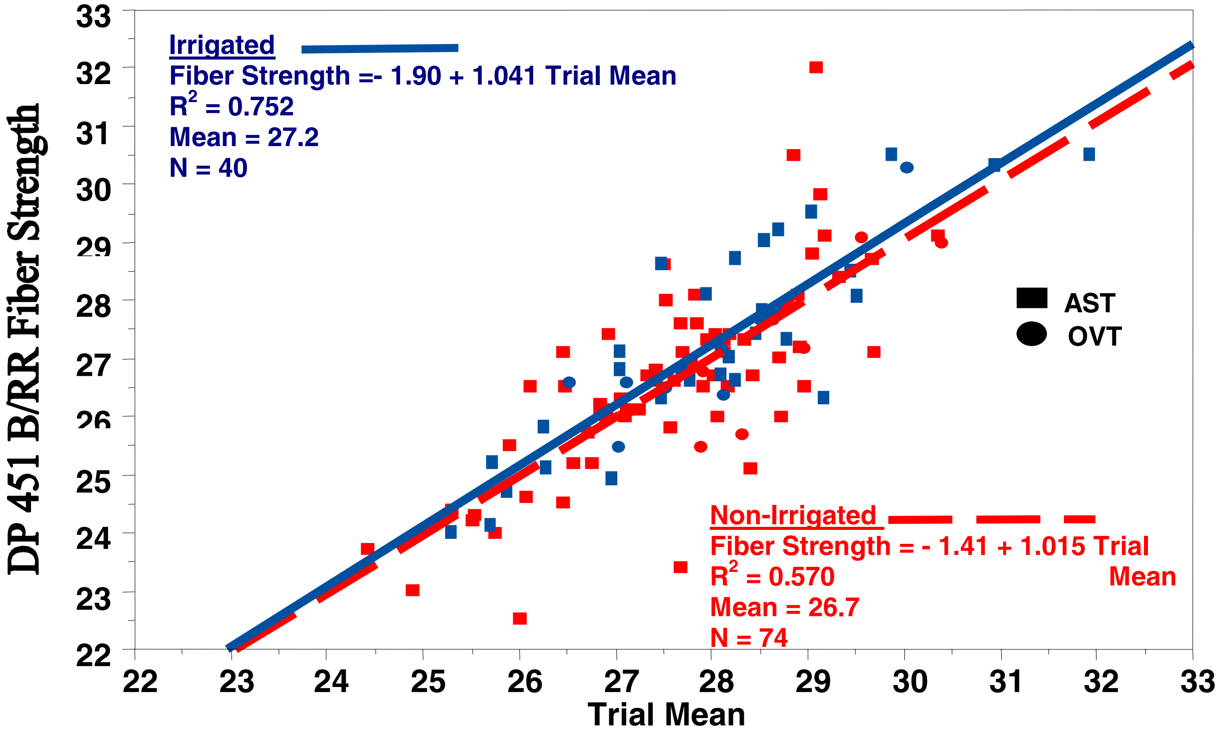

Figure 3. Fiber strength stability lines for DP 451 B/RR under irrigated versus non-irrigated environments regressed against the mean of all varieties in the respective data subset. Irrigated regression line is represented by the solid line, while the non-irrigated regression line is depicted by the dashed line. Data collected from 1998 through December 2001.

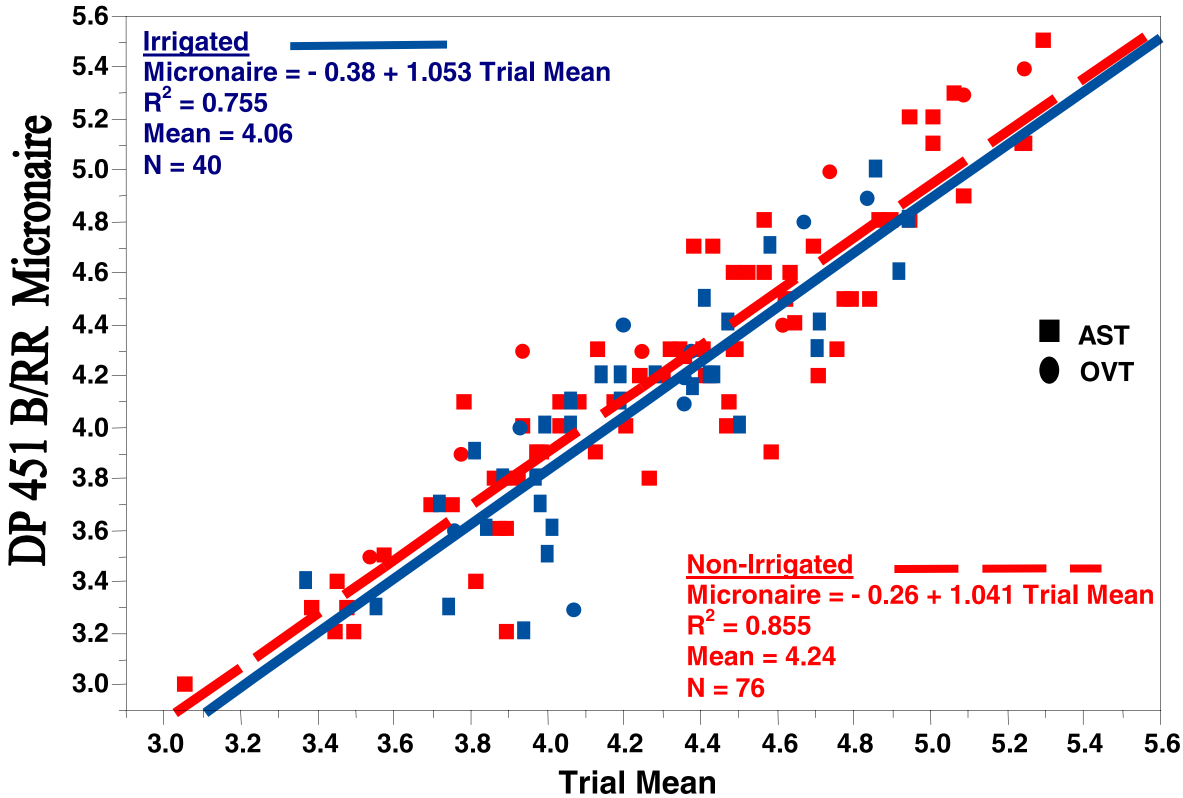

Figure 4. Micronaire stability lines for DP 451 B/RR under irrigated versus non-irrigated environments regressed against the mean of all varieties in the respective data subset. Irrigated regression line is represented by the solid line, while the non-irrigated regression line is depicted by the dashed line. Data collected from 1998 through December 2001.

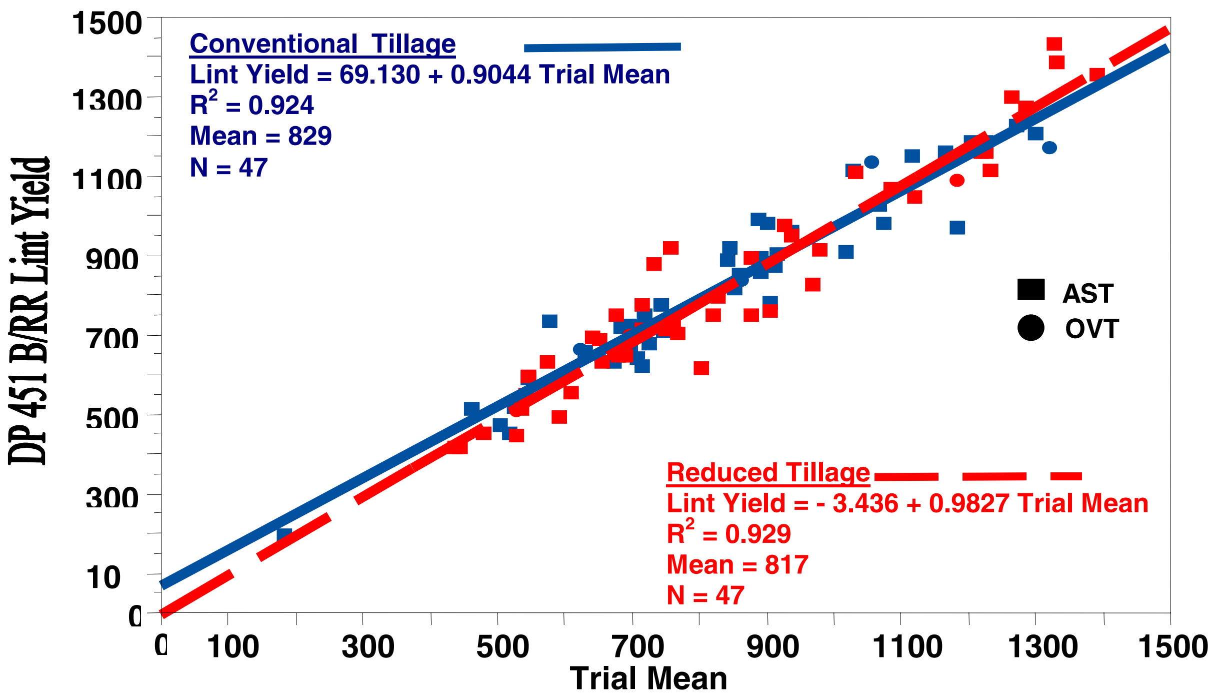

Figure 5. Yield stability lines for DP 451 B/RR under conventional tillage versus reduced-tillage environments regressed against the mean of all varieties in the respective data set. Conventional tillage regression line is represented by the solid line, while the reduced-tillage regression line is depicted by the dashed line. Data collected from 1997 through December 2001.

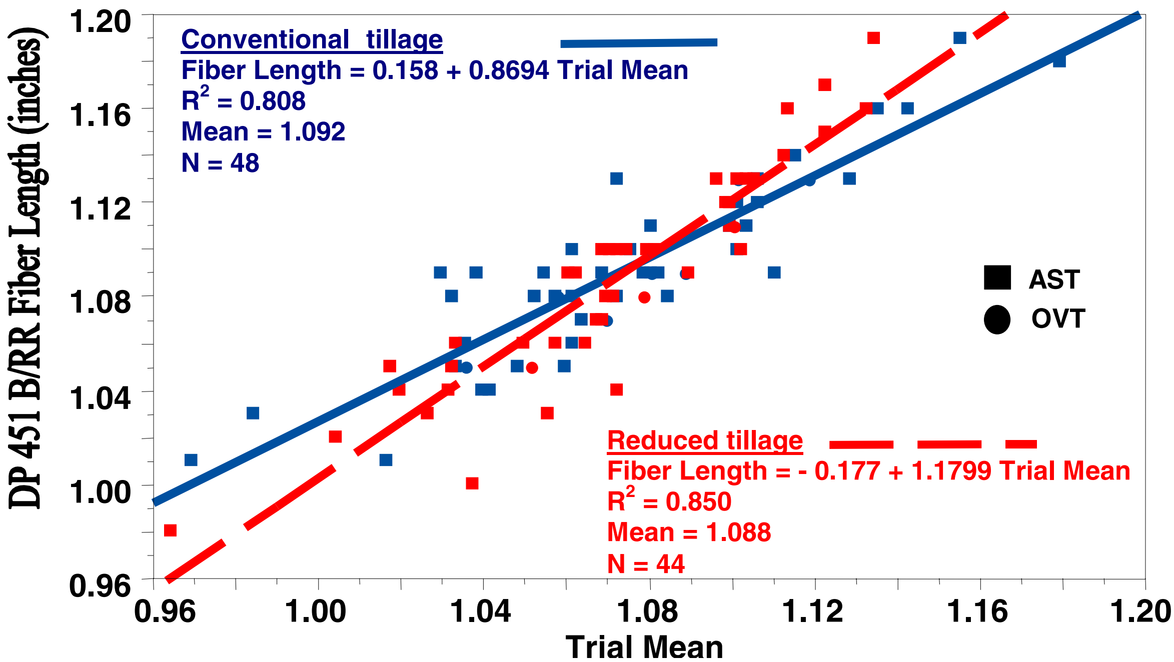

Figure 6. Fiber length stability lines for DP 451 B/RR under conventional tillage versus reduced-tillage environments regressed against the mean of all varieties in the respective data subset. Conventional tillage regression line is represented by the solid line, while the reduced-tillage regression line is depicted by the dashed line. Data collected from 1997 through December 2001.

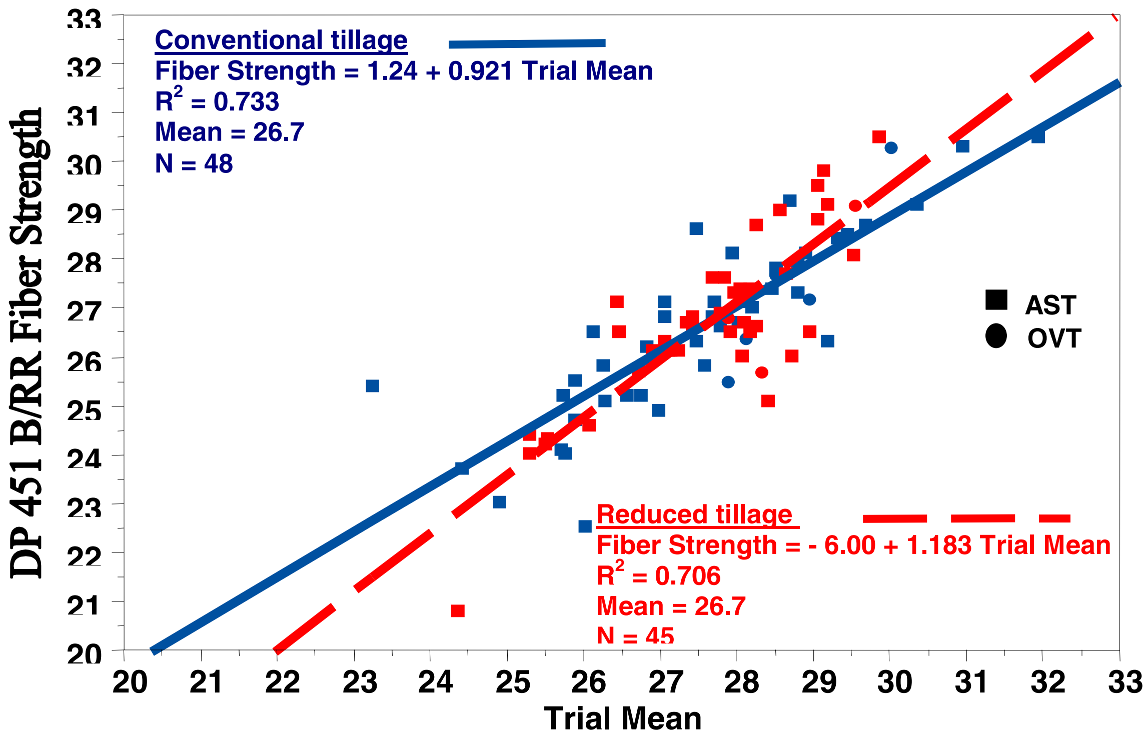

Figure 7. Fiber strength stability lines for DP 451 B/RR under conventional tillage versus reduced-tillage environments regressed against the mean of all varieties in the respective data subset. Conventional tillage regression line is represented by the solid line, while the reduced-tillage regression line is depicted by the dashed line. Data collected from 1997 through December 2001.

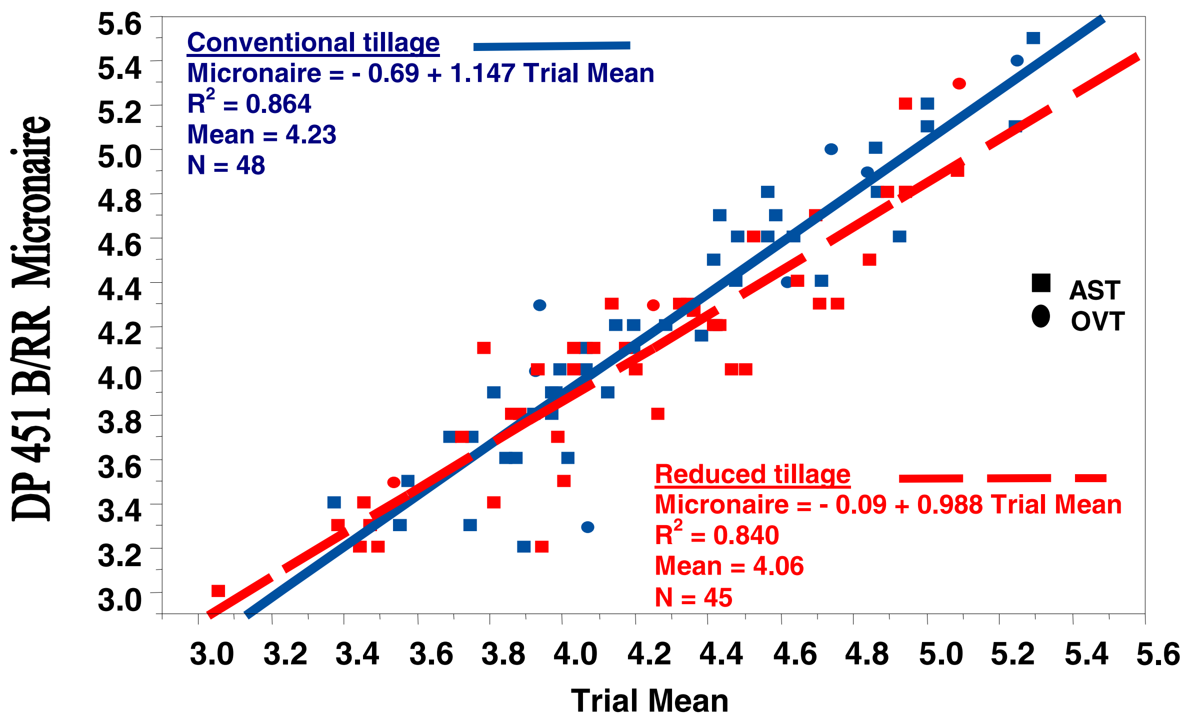

Figure 8. Micronaire stability lines for DP 451 B/RR under conventional tillage versus reduced-tillage environments regressed against the mean of all varieties in the respective data subset. Conventional tillage regression line is represented by the solid line, while the reduced-tillage regression line is depicted by the dashed line. Data collected from 1997 through December 2001.