YIELD AND STABILITY OF COTTON CULTIVARS AT THREE WEST TENNESSEE LOCATIONS

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Abstract

Lint yield potential, maturity, and stability of performance are important varietal traits to Tennessee cotton producers. Until recently, the stability of yield over years and locations has not been reported in performance trial reports. The objective of this study was to evaluate nineteen cotton varieties for yield and stability over nine environments that ranged in mean productivity from 371 to 1478 lb lint/acre. The variety yield trials were grown on the West Tennessee Experiment Station near Jackson, on the Milan Experiment Station near Milan, and on the Ames Plantation near Grand Junction during 1993, 1994, and 1995. The MATMODEL™ program was used to run an AMMI analysis on lint yield and the STABLE program was used to calculate the stability variance (σ_i^2) and yield-stability (YS_i) statistics. The AMMI1 biplot indicated that the GE interaction was related to varietal maturity and environmental season length. The two latest varieties (ST887 and SG501) had positive PCA1 scores and the four earliest varieties (ST132, H1215, H1244, and H1220) had negative scores. Only three of the nine environments had positive scores. The four earliest varieties were also the highest yielding; however, the σ_i^2 statistic was significant for each indicating that they were also unstable. H1244, H1220, ST474, and ST132 were the most unstable varieties as their σ_i^2 was at least 10X that of DP50. SG404 and DP50 were the most stable varieties as indicated by σ_i^2 of 3,505 and 3,914. Five varieties (H1215, SG404, H1220, SG125, and H1244) were better than DP50 in the tradeoff between yield and stability as measured by YS_i. H1215 was the most stable of the earliest, highest yielding varieties while SG404 was the most stable variety with above average yield. A TN cotton producer should balance his variety portfolio between potentially higher yielding varieties and consistently (yet possibly lower) yielding varieties as an investor would balance the ratio of stocks and bonds.

Introduction

Lint yield potential, maturity, and reliability of performance (stability) are important criteria that Tennessee cotton producers use to decide which varieties to plant. The UT Agricultural Extension Service reports lint yield and earliness data from yield trials and makes recommendations based upon 3-year averages; however, the stability of yield over years and locations (environments) has not entered into these recommendations until recently.

The interaction of varieties with environments is almost invariably significant with varietal rankings changing with environmental conditions. When the genotype X environment (GE) interaction is significant, recommendations based solely upon the mean may not be adequate. The traditional analysis of variance (ANOVA) is used to identify the presence of GE interactions, but it does not analyze or characterize the nature of the interaction.

The additive main effects and multiplicative interaction (AMMI) model is a statistical hybrid between ANOVA and principal component analysis (PCA) that provides a more complete analysis of multi-environment data (Zobel et al., 1988). AMMI analysis uses ANOVA for the main effects and then partitions the environment X variety interaction into one or more interaction PCA axes. The AMMI biplot of means versus PCA scores often provides biological insight into the nature of the GE interaction, particularly when it is combined with meteorlogic, geographic, and genotypic data (Zobel, 1990).

Numerous statistical measures have been developed to measure varietal differences in the consistency of response to environments (Pinthus, 1973; Nassar and Huhn, 1987; Lin and Binns, 1988; and Kang and Pham, 1991). The stability variance statistic (σ_i^2) is a measure of the contribution that each variety makes to the overall GE interaction (Shukla, 1972). The yield-stability statistic (YS_i) combines yield and stability (Kang, 1993). YS_i is calculated by deducting the rank of a varietal mean by the stability rating which is determined by the probability of σ_i^2 being significant.

The objective of this study was to analyze the yield stability of cotton varieties grown in the Tennessee cotton variety yield trials between 1993 and 1995.

Materials and Methods

Cotton variety yield trials were grown on the West Tennessee Experiment Station at Jackson, on the Milan Experiment Station at Milan, and on the Ames Plantation at Grand Junction during 1993, 1994, and 1995. There were nineteen varieties that were grown in all nine environments including eight newer varieties and eleven older varieties. Except for the trial at Ames Plantation in 1993, the variety trials consisted of four reps of two-row plots that were harvested twice approximately two weeks apart. The 1993 Ames trial was harvested only once and had five reps of which the first four were analyzed here.

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Lint yield data were analyzed using ANOVA, AMMI, and stability analyses. The MATMODEL™ computer program (Gauch and Furnas, 1991) was used to run the AMMI analysis and the STABLE computer program (Kang and Magari, 1995) was used to calculate the σ_i^2 and YS_i statistics

Results

All main effects and interactions were significant in the traditional ANOVA (Table 1). The significant interactions between varieties, years, and locations indicated that the varieties performed differently in the different environments and that the data would be difficult to summarize over environments.

AMMI

The validating mode of MATMODEL™ with 100 runs of three random reps indicated that the AMMI model with only one PCA axis (AMMI1) provided the most predictive accuracy with the remaining validation rep. The fitting mode of MATMODEL™ was then run for the AMMI1 model (Table 2) and the AMMI1 biplot was generated from the output of means and PCA1 scores (Fig. 1). The X axis was compressed to emphasize varietal effects. The environment means actually ranged from 371 to 1478 lb lint/acre.

The AMMI1 biplot illustrates a significant portion of the GE interaction. The interaction of a variety with a particular environment may be positive or negative as determined by multiplying their respective PCA1 scores. The positive interactions of H1220 and H1244 with Milan in 1995 and of ST887, DES119, and CB1135 with Milan and Jackson in 1994 were primary sources of variation as were the negative interactions of H1220 and H1244 with Milan and Jackson in 1994 and of ST887, DES119, and CB1135 with Milan in 1995. Varieties with PCA1 scores near zero were relatively stable in these nine environments.

The AMMI1 biplot indicated that the GE interaction was related to varietal maturity and environmental season length. The four earliest varieties (ST132, H1215, H1244, and H1220) had negative PCA1 scores and the three latest varieties (ST887, SG501, and DP51) had positive PCA1 scores. Of the nine environments only Milan and Jackson in 1994 and Jackson in 1993 had positive PCA1 scores.

Yield and Earliness

The newer varieties H1220, H1215, H1244, ST474, and SG404 yielded significantly more than DP50 (Table 3). These five varieties, along with SG125 and H1330, were also significantly earlier (higher percent first harvest) than DP50. Of the older varieties only ST132 was significantly higher yielding and earlier than DP50. There was a strong correlation (0.75) between yield and earliness in these cotton variety yield trials with the four earliest varieties also having the highest mean yields.

Stability

The stability variance was significant for all varieties except C-40, CB232, DP20, DP50, SG125, SG404, and SG501 (Table 3). Each of these varieties except C-40 and SG501 were also determined to be stable (PCA1 near 0) by the AMMI1 biplot. Considering that AMMI1 analysis partitioned only 45% of the interaction sum of squares, there was close agreement with the σ_i^2 statistic. H1244, H1220, ST474, ST132, and ST887 were the most unstable varieties with each having a σ_i^2 more than 10X that of DP50. SG404 and DP50 had the lowest σ_i^2 at 3,505 and 3,914 and contributed very little to the GE interaction.

The YS_i statistic selected ten varieties as having a better than average combination of yield and stability (Table 3). H1215, SG404, H1220, SG125, and H1244 had a higher YS_i than DP50. Even though H1244 outyielded SG125 by 95 lb lint/acre, it was also the most unstable variety while SG125 was one of the more stable ones. The identical US statistics for these two varieties illustrates the tradeoff between yield and stablity in the YS statistic.

Discussion

Over the past several years, DP50 has been grown on a large portion of the cotton acreage in the Mississippi River Delta. Many producers consider this to be a fail-safe (stable) cotton variety, which is confirmed by its low σ_i^2. This statistic may be used to indicate the relative stability of newer varieties and give producers more confidence in trying newer, high yielding varieties. There were five varieties that were better than DP50 in the tradeoff between yield and stability. Of the earliest and highest yielding varieties, only H1215 had a σ_i^2 that was lower than the average. SG404 was the most stable variety with above average yield. A TN cotton producer should balance his variety portfolio between potentially higher yield and consistent (yet possibly lower) yield as an investor would balance the ratio of stocks and bonds in his portfolio.

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Table 1. Analysis of variance for lint yield of cotton varieties grown at the Jackson, Milan, and Ames locations in Tennessee between 1993 and 1995.

Source	df	MS(x1,000)	F
Years	2	13,461	188.2 **
Locations	2	13,928	194.7 **
Yr*Loc	4	5,258	73.5 **
Varieties	18	168	15.2 **
Yr*Var	36	48	4.3 **
Loc*Var	36	28	2.5 **
Yr*Loc*Var	72	27	2.4 **

Table 2. AMMI1 analysis for lint yield of cotton varieties grown at the Jackson, Milan, and Ames locations in Tennessee between 1993 and 1995.

Source	df	MS(x1,000)	F
Environments	8	9,476	132.5 **
Varieties	18	168	15.2 **
Env*Var	144	33	2.9 **
PCA	25	85	7.7 **
Residual	119	22	1.9 **

Table 3. Lint yield, earliness, stability variance, and yield-stability statistics for nineteen varieties grown at the Jackson, Milan, and Ames locations in Tennessee between 1993 and 1995.

Variety	# Lint/ acre	% First Harvest	Stability Variance	Yield-Stability
C-40	936	77.7	20,826	-3
CB232	989	77.5	14,865	9 +
CB333	954	80.8	35,476 **	-7
CB1135	962	79.5	21,903 *	0
DP20	984	78.9	12,899	8 +
DP50	998	78.0	3,914	10 +
DP51	1003	76.5	28,941 **	3
DES119	959	81.0	38,590 **	-5
H1215	1143	86.3	23,755 *	17 +
H1220	1150	84.1	60,527 **	14 +
H1244	1113	84.6	107,664 **	12 +
H1330	979	83.5	35,701 **	-1
SG501	945	74.7	13,437	0
SG125	1018	82.0	19,404	12 +
SG404	1048	82.8	3,505	15 +
ST132	1085	86.9	46,147 **	10 +
ST453	973	79.4	33,999 **	-3
ST887	955	74.7	41,642 **	-6
ST474	1082	80.8	55,504 **	9 +
$LSD_{0.05}$	41	1.7	NA	NA

+ Selected by STABLE as having better than average yield-stability.

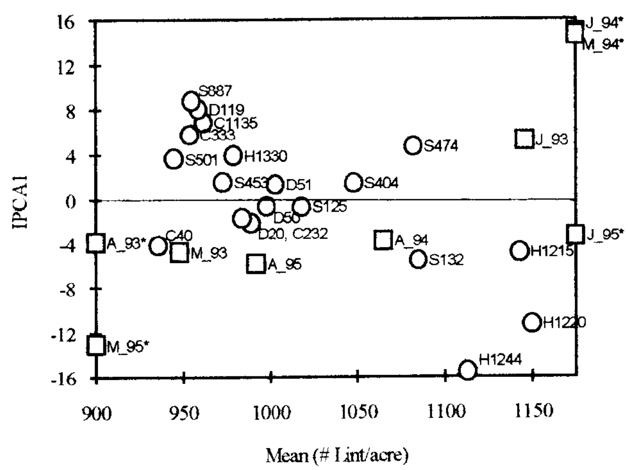

Fig. 1. AMMI1 biplot of environmental and varietal lint yield means versus their PCA1 scores. The environments marked with an asterisk (*) had means beyond the X axis scale.