STABLE STATISTICS FOR COTTON VARIETIES GROWN IN THE MIDSOUTH, SOUTHEAST, NORTH AND TEXAS FROM 1993-1995

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Abstract

Yield and yield stability are separate but important considerations in the selection of which variety, by producers, to plant and to plant breeders in their variety development programs. Historically, yield has been the focus of most varietal comparisons and only in the last few years have stability (genotype x environment interaction) analyses started to appear in State variety trial summary publications. The recent integration of these two measures of performance into a yield-stability statistic (YS_i) that provides a single selection criterion may facilitate varietal selection to the benefit of both producers and plant breeders. An additional benefit may arise from considering varietal performance in a regional context rather than on a state by state basis. State cotton variety yield trial test results from 10 states over the years 1993-1995 were grouped according to production region (MidSouth, Southeast, North, Texas) and YS_i statistics calculated to identify varieties with a superior combination of yield and yield stability. The ANOVA indicated highly significant differences between environments in all four regions and highly significant genotype differences in all regions except Texas. Only in the Southeast and MidSouth was the genotype x environment interaction significant. Stability variance was significant only for STV 132 in the MidSouth, Southeast and Texas; Hyperformer HS-46 in the MidSouth and Texas; DPL 5415 in the MidSouth; and Georgia King in the Southeast. The most stable genotypes across all four regions were DPL 5690 and DPL 51. Varieties with the highest YS_i statistics across all four regions were STV LA887, SG 125, SG 501, DPL 51, SG 404, DPL 20 and DPL 5690.

Introduction

The yield of a variety is a combination of both its genetic potential and the nature of the environment in which it is grown. The interaction of these two factors contributes to the frequently observed phenomenon that the relative performance of genotypes varies in different environments complicating the genetic analysis of performance and also reducing the efficiency of plant breeding efforts (Cooper and Byth 1996). Attempts to understand this interaction of genotype and environment (GxE) have assumed many forms (Finlay and Wilkinson 1963; Shukla 1972; Mungomery et al., 1974; Zobel et al., 1988).

While the dissection of GxE and an understanding of a genotype's stability and/or its contribution to GxE is valuable, this needs to be combined with information on yield per se if the true worth of a specific genotype is to be fully assessed. Lin and Binns (1988) do consider yield in their development of a cultivar superiority measure but the basis for their measurement of cultivar stability is based on mean yield differences and does not partition the observed variability into its components nor test them. Only recently has an attempt been made to combine information on genotype stability and yield into a single selection criteria (Kang 1993). The yield-stability statistic (YS_i) of Kang (1993) provides an integrated measure of a genotype's yield and stability by combining information on the rank of a genotype's mean yield with a stability rating based upon the probability of its stability variance statistic being significant. The stability variance statistic is a measure of a variety's contribution to the overall GxE interaction (Shukla 1972).

While previous reports on the occurrence of GxE in cotton in the U.S. are available (McPherson and Gwathmey 1996; Moore 1994) these have all concentrated on environments within a state. Information on the stability of varieties across states is not available. In this study we report on an analysis of cotton variety stability within the major Upland cotton producing regions and across the entire Upland cotton producing belt.

Materials and Methods

Data was collected from official State Cotton Variety Test Reports for the years 1993-1995. From these reports, reduced data sets were constructed using defined production regions (North - Missouri, Tennessee; Texas; Southeast - Alabama, Georgia, North Carolina, South Carolina; and MidSouth - Arkansas, Louisiana, Mississippi). In addition to the regional groupings, data sets were further reducing by requiring that any given genotype or location, within a region, be represented across all three years; this was done so that the data sets would be balanced.

The reduced data sets were analyzed using STABLE (Kang and Magari 1995) using environmental index as the covariate. Briefly, STABLE first performs an ANOVA and partitions GxE into heterogeneity and residual components. Variety mean yields across environments are then ranked from lowest (score of 1) to highest (score of *n*). Yield ranks are adjusted after calculation of a protected LSD with varieties having mean yields > overall mean yield (OMY) receiving an adjustment factor of +1, +2 for mean yield $\geq$ 1 LSD above OMY, +3 for mean yield $\geq$ 2 LSD above OMY, -1 for mean yield < OMY, -2 for mean yield $\leq$ 1 LSD below OMY, and -3 for mean yield $\leq$ 2 LSD below OMY. The

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contribution of each variety to GxE is determined by calculating its stability variance (Shukla 1972). If GxE is significant, a variety that does not contribute significantly to GxE receives a stability rating of 0. If the stability variance is significant at either the p=0.1, 0.05 or 0.01 levels, stability ratings of -2, -4 and -8, respectively, are assigned. The YS_i statistic is the sum of the adjusted yield rank and the stability rating. A variety is selected as desirable by YS_i if its YS_i value is greater than the mean YS_i of all of the varieties.

Results and Discussion

The ANOVA's for each of the four regions are presented in tables 1-4. Genotypes were significant in all regions except Texas. Environments were highly significant in all four regions and were by far the largest contributors to total variance. Genotype x environment interactions were only significant in the MidSouth and Southeast. Heterogeneity was nonsignificant in all regions indicating that environmental index could not adequately explain GxE when it was significant.

Stability variance statistics (σ^2_i) for the four regions are presented in tables 5-8. Except for the Northern region where none of the genotypes were significant, 2-3 genotypes were found in the other regions to be significant contributors to GxE. Across all four regions, STV 132 and Hyperformer HS-46 were found to be the largest contributors to GxE. The most stable genotypes across all four regions, based on σ^2_i were DPL 5690 and DPL 51.
The lack of significant GxE and any significant genotype stability variances in the Northern region means that selection among the genotypes tested could be based strictly on yield. The two earliest varieties in the North data set were selected by YS_i: STV 132 and DPL 20 (table 5). In Texas, the YS_i selected genotypes (table 6) were again the highest yielding even after STV 132 was penalized for having a significant stability variance. The importance of stable genotype performance across environments is evident in the Southeast region where the highest yielding genotype, GA King, was not selected based upon YS_i due to its very large and highly significant stability variance (table 7). In the MidSouth, all of the YS_i selected genotypes (table 8) were nonsignificant contributors to the observed GxE. DPL 50 was found to be very stable across MidSouth environments.

Based upon the STABLE (YS_i) statistics, the genotypes combining the best combination of yield and stability of performance across two or more environments were STV LA887, STV 132, DPL 51 and DPL 5690. The early maturity of STV 132 is evident by its selection in regions were this characteristic is important. In other regions, though, it was found to be undesirable. When YS_i statistics are summed over all four regions, the top four varieties selected were STV LA887, SG 125, SG 501 and DPL 51. This interpretation is only tentative since not all genotypes were able to be analyzed in all four regions. The use of these genotypes in plant breeding efforts to develop high yielding, widely adapted genotypes should be considered.

Table 1. Analysis of variance of lint yield for cotton varieties grown in the North from 1993-1995.

Source	d.f.	Mean Squares	F
Total	23		
Genotypes	5	26920	6.6109**
Environments	3	617662	83.5128**
Interaction	15	4072	0.5506ns
Heterogeneity	5	1976	0.3860ns
Residual	10	5120	0.6922ns
Pooled Error	40	7396	

*,** Significant at 0.05 and 0.01 levels, respectively.

Table 2. Analysis of variance of lint yield for cotton varieties grown in Texas from 1993-1995.

Source	d.f.	Mean Squares	F
Total	34		
Genotypes	6	59608	2.1163ns
Environments	4	1347981	71.4718**
Interaction	24	28167	1.4934ns
Heterogeneity	6	32121	1.1964ns
Residual	18	26879	1.4235ns
Pooled Error	60	18860	

*,** Significant at 0.05 and 0.01 levels, respectively.

Table 3. Analysis of variance of lint yield for cotton varieties grown in the Southeast from 1993-1995.

Source	d.f.	Mean Squares	F
Total	95		
Genotypes	7	64697	4.2437**
Environments	11	1174697	144.8623**
Interaction	77	15245	1.8801**
Heterogeneity	7	3266	0.1986ns
Residual	70	16443	2.0278**
Pooled Error	168	8109	

*,** Significant at 0.05 and 0.01 levels, respectively.

Table 4. Analysis of variance of lint yield for cotton varieties grown in the MidSouth from 1993-1995.

Source	d.f.	Mean Squares	F
Total	119		
Genotypes	9	95157	9.2001**
Environments	11	1085350	169.3089**
Interaction	99	10343	1.6135**
Heterogeneity	9	11292	1.1019ns
Residual	90	10248	1.5987**
Pooled Error	216	6410	

*,** Significant at 0.05 and 0.01 levels, respectively.

Table 5. Stability variance statistics for lint yield for cotton varieties grown in the North from 1993-1995.

Variety	Mean	Yield Rank	Adj. to Rank	σ^2_i	Stab. Score	YS_i
S T V 132	1082 a	6	3	2987ns	0	9 +
DPL 20	1005 b	5	3	1624ns	0	8 +
DPL 50	993 b	4	- 3	5236ns	0	1
SG 501	985 b	3	- 3	8646ns	0	0
S T V LA887	962 b	2	- 3	3111ns	0	- 1
T e r r a C40	947 b	1	- 3	2831ns	0	- 2

Means followed by the same letter are not statistically different at p=0.05.
*,** Significant at 0.05 and 0.01 levels, respectively.

Table 6. Stability variance statistics for lint yield for cotton varieties grown in Texas from 1993-1995.

Variety	Mean	Yield Rank	Adj. to Rank	σ^2_i	Stab. Score	YS_i
STV LA877	1041 a	7	3	40159ns	0	10 +
STV 132	979 ab	6	3	50338*	- 4	5 +
DPL 5690	921 bc	5	- 3	1553ns	0	2 +
DPL 50	920 bc	4	- 3	35850ns	0	1
DES 119	912 bc	3	- 3	14089ns	0	0
DPL 51	869 c	2	- 3	6416ns	0	- 1
HY HS-46	861 c	1	- 3	51871*	- 4	- 6

Means followed by the same letter are not statistically different at p=0.05.
*,** Significant at 0.05 and 0.01 levels, respectively.

Table 7. Stability variance statistics for lint yield for cotton varieties grown in the Southeast from 1993-1995.

Variety	Mean	Yield Rank	Adj. to Rank	σ^2_i	Stab. Score	YS_i
GA King	1050 a	8	2	70999**	- 8	2
STV LA887	1038ab	7	1	5113ns	0	8 +
DPL 5415	1026ab	6	1	10280ns	0	7 +
DPL 51	1025ab	5	1	6389ns	0	6 +
DPL 5690	1025ab	4	1	845ns	0	5 +
SG 1001	1006 b	3	- 1	1237ns	0	2
HY HS-46	1003 b	2	- 1	8215ns	0	1
STV 132	913 c	1	- 3	18885**	- 8	- 10

Means followed by the same letter are not statistically different at p=0.05.
*,** Significant at 0.05 and 0.01 respectively.

Table 8. Stability variance statistics for lint yield for cotton varieties grown in the MidSouth from 1993-1995.

Variety	Mean	Yield Rank	Adj. to Rank	σ^2_i	Stab. Score	YS_i
SG 125	1109 a	10	3	7204ns	0	13 +
SG 501	1058 b	9	2	3933ns	0	11 +
SG 404	1036bc	8	1	3233ns	0	9 +
STV LA887	1031bcd	7	1	7906ns	0	8 +
STV 132	1019cde	6	1	14899**	- 8	- 1
DPL 51	1008cde	5	- 1	4323ns	0	+ 4
DPL 5415	996def	4	- 1	31344**	- 8	- 5
DPL 50	992ef	3	- 1	109ns	0	2
HYHS-46	966 f	2	- 2	24492**	- 8	- 8
HYHS-23	920 g	1	- 3	5998ns	0	- 2

Means followed by the same letter are not statistically different at p=0.05.
*,** Significant at 0.05 and 0.01 respectively.

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