AMMI Biplot Analysis in Cotton (*Gossypium hirsutum* L.) Genotypes for Genotype X Environment Interaction at Four Agro-ecologies in Telangana State

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Authors' contributions

*This work was carried out in collaboration among all authors. Author NL conducted the study,
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Authors AS, VTR, YP, MVK, PIR and BR conducted the study at different locations and prepared data
for pooled analysis. Authors PRRR and PJMR provided all inputs and infra structure facility to carry
out the experiment and writing this article. All authors read and approved the final manuscript.*

Original Research Article

ABSTRACT

The objective of this study was to determine the genotype × environment interaction (GEI) and
stability performance of eight promising cotton genotypes at four agro-ecologies in Telangana State.
The experimental material consisting of eight genotypes were planted in randomized block design

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replicating thrice in four diverse environments of Telangana state during 2017, *Kharif* season. The present investigation was carried out in four diverse environments of Telangana state *viz.* RARS, Warangal, ARS, Adilabad, ARS, Modhole and RARS, Palem (Professor Jayashankar Telangana State Agricultural University) during 2017, *Kharif* season. The study was conducted at four diversified agro-ecologies of Telangana State. The experimental material comprised of eight genotypes viz., WGCV-109, ADB-638, WGCV-122, Narasimha, WGCV-119, WGCV-119, Srirama, WGCV-48 and ADB 645. First pooled analysis of variance was carried out to know the significance variation in genotype x environment interaction followed by AMMI analysis for genotype x environment interaction studies. Analysis of variance was significant for environments and (G x E) components indicating the use fullness of AMMI analysis in identifying the stable genotypes. Among the eight cotton genotypes, WGCV-109, Narasimha and ADB-645 were found to be best yielders over environments whereas the genotypes G7 (WGCV-48) and G4 (Narasimha) found to be stable. Most of the genotypes showed environment specificity. As a result, almost all of the evaluated genotypes were affected by the genotype x environment interaction effects, hence no genotype had superior performance in all environments.

1. INTRODUCTION

Cotton is an important natural fibre crop of global importance cultivated in tropical and subtropical regions of the world. In breeding programmes, the development of new cultivars and suitability of these genotypes to different environmental situations, are considered as important objectives but estimating the genotype x environment interaction forms the success of stable genotypes identification. There are several methods to estimate the stability of a genotype across environments by determining GxE interaction effects. Among these, AMMI analysis is the most recent and widely exploited in different crops for the identification of stable genotypes over locations. The results of AMMI (Additive Main Effects and Multiplicative Interaction) analysis are useful in identifying the stable genotypes to specific environments which can be utilized in breeding program [1]. AMMI analysis is one of the most recent technique exploited to a greater extent in cotton [2-5].

To achieve this, a large number of genotypes (G) is tested annually in different environments (E), before final recommendation and multiplication. In most cases, these environments vary substantially, and there are interactions between genotypes and environments (GE), that arise from differential genotypic responses to the environment. Understanding GE interactions affords an assessment of the real impact of selection and ensures greater reliability when recommending genotypes to maximize productivity and other agronomic traits of interest in a specific location or group of environments [6].

2. MATERIALS AND METHODS

In the present investigation, the experiment material comprised a total of eight cotton genotypes developed based on yield, yield attributing traits and evaluated through preliminary yield trials. The present experiment conducted at four diverse environments of Telangana state *i.e.* Warangal, Adilabad, Mudhole and Palem during the year 2017. The experiments were laid in randomized block design with three replications. Standard package of practices were followed to maintain a good crop in the field. The details of genotypes and environments are presented in Table 1. The data was subjected to analysis of variance and then taken for AMMI analysis for identification of stable genotypes.

Additive main effects and multiplicative interaction (AMMI) model calculates genotypes and environments additive (main) effects using analysis of variance and then analyzes the residual from this model (interaction) using principal components analysis (PCA). AMMI model is a hybrid model with graphical representation of the numerical results which allows interpretation of the underlying causes of G x E interaction. With the significant G x E interaction, the AMMI model was employed which combines standard analysis of variance with PC analysis to investigate the G x E interaction. The ANOVA and Stability analysis for yield trait was carried out by using the AMMI

model R-packages 1.5, PB Tools 1.4 version IRRI.

3. RESULTS AND DISCUSSION

The pooled analysis of variance for cotton yield over four environments is presented in Table 2. Analysis of variance was significant for environments and (G x E) components indicating the appropriateness of AMMI analysis in identifying the stable genotypes. The additive main effects and multiplicative interaction (AMMI) model calculates genotypes and environment additive (main) effects using analysis of variance and then analyze the residual from this model using principal component analysis (PCA). The AMMI model is a graphical representation of the numerical results (biplot analysis), allows a straight forward interpretation of the underlying causes of G x E interaction. Cotton yield mean data along with PCA 1 (Principal Component Analysis 1) and IPCA 2 values for eight genotypes are presented in Table 3.

The PCA 1 explained 65. 9% of the G×E interaction, PCA 2, 19.6% and PCA 3, 14.5%. The cumulative captured by first two PCA axis was 85.5% of total genotype x environment interaction (Table 2).

In the AMMI 1 biplot, the usual interpretation of biplot is that the displacements along the abscissa indicate differences in main (additive) effects, whereas displacements along the ordinate indicate differences in interaction effects. Genotypes that group together have similar adaptation while environments which group together influences the genotypes in the same way [7].

In AMMI-I biplot (Fig. 1), gnotypes and environments on the same parallel lines have similar yields and a genotype or environment on the right side of the midpoint of this axis has higher yields than those of left hand side. Accordingly, among the cotton genotypes, G8 and G6 exhibited high yield of positive IPCA1 score, G1 had highest cotton yield with negative IPCA1 score. Out of eight cotton genotypes G11 being the overall best genotype in yield specially adapted the corresponding environment 4. Among eight genotypes, G7 was with near zero IPCA1 score and hence had less interaction with the environments with above average yield performance. Among environments, E2 exhibited near zero IPCA1 score and hence had small interaction effects indicating that few genotypes performed well in this location. Of the environments, however, E1 and E4 were most favorable environments for most genotypes. The cotton genotypes G6 and G8 performed well under environment E1, while E3 was good for only one genotype G2.

Table 1. Genotypes and environmental conditions details

S. no.	Genotype code	Genotype name	Environment code	Environment name	Latitude	Longitude	*MSL
1	G1	WGCV-109	E1	Warangal	17. 96°'N	79.59°E	270.00 m
2	G2	ADB-638	E2	Adilabad	19.66° N	78.53° E	268.80 m
3	G3	WGCV-122	E3	Mudhole	18.97° N	77.91° E	346.00 m
4	G4	Narasimha	E4	Palem	16.54°N	78.20°E	642.00 m
5	G5	WGCV-119					
6	G6	Srirama					
7	G7	WGCV-48					
8	G8	ADB-645					

*MSL- Mean Sea Level

Table 2. AMMI analysis of variance for cotton yield (kg/ha)

Source	d.f	SS	MSS
Varieties	7	102281.52	14611.64
Environments	3	2225116.58	741705.52*
Varieties X Environments	21	3547051.79	168907.22**
PC1	9	2337978.0	259775.3
PC2	7	694391.6	99198.8
PC3	5	515332.0	103066.4
Error	64	1971699.88	30807.81
Total	95	7846149.79	

d.f- degrees of freedom, SS-Sum of squares, MSS- Mean sum of squares

**Table 3. Genotype Means with PCA1 and PCA2 values for yield (kg ha⁻¹) over environments**

S. No.	Genotpe	PCA1 values	PCA2 values	Mean Yield (kg ha⁻¹)
1	WGCV-109	-16.1765	-4.216	1662
2	ADB-638	13.6275	4.3973	1570
3	WGCV-122	-4.2156	12.285	1575
4	Narasimha	-3.1372	-11.650	1650
5	WGCV-119	-15.00	9.112	1610
6	Srirama	2.3529	-7.752	1640
7	WGCV-48	-1.07843	-5.304	1630
8	ADB-645	13.5294	2.493	1649
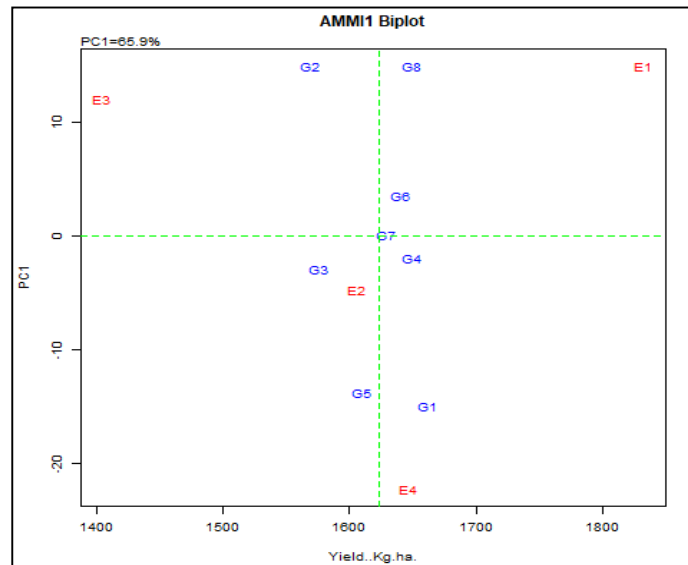
Fig. 1. AMMI biplot for Cotton yield (kg ha⁻¹) of eight Cotton genotypes (G) and four environments (E)

The AMMI model was employed which combines standard analysis of variance with PC analysis to investigate the G x E interaction [8] to know stability of genotypes. In AMMI 2 biplot (Fig. 2), the environmental scores are joined to the origin by side lines. Sites with short spokes do not exert strong interactive forces. Those with long spokes exert strong interaction. The genotypes close to ordinate expressed general adaptation, whereas the further genotypes depicted more specific adaptation to environments [8]. Hence, environments E1, E3 and E4 exerted strong interaction forces, so E2 did not provide useful information about the genotypes as did other environments. On the other hand, the genotypes near the origin are not sensitive to environmental interaction and those distant from the origins are sensitive and have large interaction. In the present case, G2, G8, G1 and G5 had more responsive since they were away from the origin whereas the genotype G7 was close to the origin and hence this was less sensitive to environmental interactive forces. The genotypes G5 (WGCV-119) and G3 (WGCV-122) may perform better in environment E2 while the genotypes G2 (ADB-638) and G8 (ADB-645) in environment E3, G1 (WGCV-109) and G4 (Narasimha) in Environment E4 and G6 (Srirama) in environment E1.

This large proportion explained by environments indicated that they were highly diverse and discriminating on the basis of the environment means [9]. These results conform to the findings of the author [10]. The environmental effects are responsible for affecting the genotype performance and are likely to cause consequences in yield performance across locations. Similar studies have been reported to have effects on cotton yield [11].
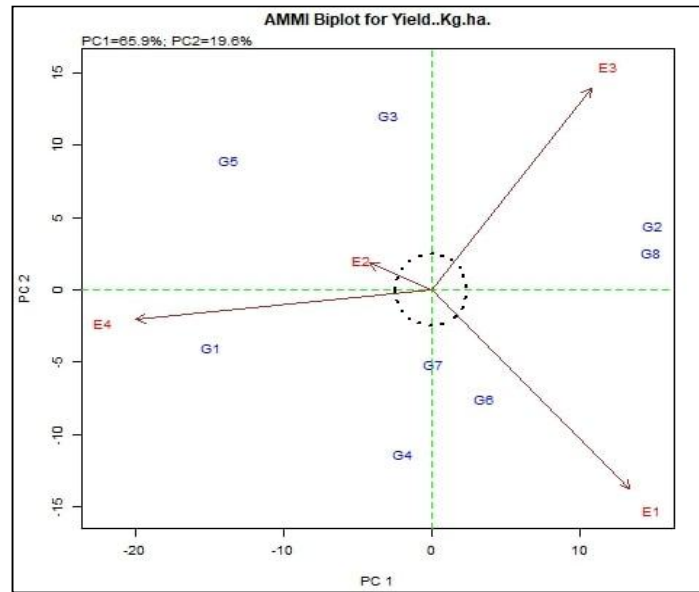
Fig. 2. AMMI-II biplot for Cotton yield (kg ha^{-1}) showing the interaction of PC1 against PC2 scores of eight Cotton genotypes (G) and four environments (E)

These results indicate that cotton breeders should consider environmental conditions and stability as a criterion for selecting high yielding cultivars [12].

4. CONCLUSION

Except the genotype WGCV-48, seven genotypes showed environment specificity. As a result, almost all of the evaluated genotypes were affected by the genotype x environment interaction effects, hence no genotype had superior performance in all environments. The highly significant genotype x environment interaction effects suggest that genotypes may be selected to specific environments. Among cotton genotypes, WGCV-109, Narasimha and ADB-645 were found to be best yielders over environments whereas the genotypes G7 (WGCV-48) and G4 (Narasimha) found to be stable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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