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Phenotypic Stability Analysis in Foxtail Millet for Quality Characters

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ABSTRACT

Twenty italian millet genotypes were evaluated for three quality characters over 16 environments (8 sowing dates with 2 fertility levels).The analysis of variance of Eberhart and Russell indicated that G×E interaction was significant for all 3 characters under study and that genotypes differed significantly. Among the AMMI component first four IPCA axis were explained most of the portion of G × E interaction than other IPCA axis for the three characters under study. The ANOVA indicated non-significant G × E interaction for carotene content and ANOVA of (Eberhart and Russell,1966) indicated non-significant G × E (linear) interaction for calcium content, when tested against pooled deviation. As per AMMI analysis the $IPCA_1$ significantly contributed to protein content, calcium content and carotene content while $IPCA_2$ contributed significantly to G × E interaction for protein content, calcium content and carotene content. This brings out clearly the advantage of AMMI ANOVA in bringing out G × E interaction through $IPCA_1$ which gets combined with error in the other two ANOVA and points out the utility of AMMI models in studying the significant G × E interaction and identifying stable genotypes for characters which so undetected in the earlier analysis. According to AMMI analyses the genotypes like GS 444 and GS 480 (for protein content); most of the genotypes (for calcium content); GS 445, GS 450 and PRD (for carotene content) are more stable because they are having IPCA score near zero that is they show less interaction with environments. According to Eberhart and Russell the genotypes like GS 488 and KDR (for protein content); GS 489, GS 463 and GS 479 (for calcium content) and GS 462 and GS 479 (carotene content) showed desirable performance.

Key words : AMMI, Foxtail millet, Stability.

Italian millet [*Setaria italica* (L.) Beauv) also known as Foxtail millet is an important minor millet belonging to the family Poaceae. It is suited to conditions of low and moderate rainfall area due to early maturity period. The ordinary ANOVA model is additive and effectively describes the main (additive) effects, while the interaction (residual from the additive model) is non-additive and requires other techniques, such as Principal Component Analysis (PCA) to identify interaction patterns. Thus ANOVA and PCA models combine to constitute the Additive Main effects and Multiplicative Interaction (AMMI) model (Gauch and Zobel, 1988). In the present study, the genotypes were examped for stability by quality traits in foxt milion.

MATERIAL AND METHODS

Twenty genotypes namely GS 440(1), GS 444 (2), GS 445 (3), GS 450 (4), GS 462 (5), GS 463 (6), GS 465 (7), GS 467 (8), GS 477 (9), GS 479 (10), GS 480 (11), GS 482(12), GS 486(13), GS 487(14), GS 488 (15), GS 489(16), Krishnadevaraya(17), Narasimharaya (18) and Srilakshmi (19) and Prasad (20) were sown during *kharif* 2009 (four sowing dates) and *rabi* 2009-10 (four sowing dates) with two fertility levels (high fertility N: 80 kg ha^{-1}, P_2O_5 20 kg ha^{-1}, K_2O 20 kg ha^{-1} and normal fertility N : 40 kg ha^{-1}, P_2O_5 20 kg ha^{-1}, K_2O 20 kg ha^{-1}), thus providing 16 environments at Agricultural College Farm, Bapatla. Material was grown in randomized block design with three replications with 3m long plots of 4 rows per genotype per replication. An inter and intra row spacing of 25 cm and 10 cm was practiced. The observations were recorded on three characters quality i.e., crude protein, calcium content and carotene content Stability parameters were analysed using regression model (Eberhart and Russell, 1966) and AMMI model (Gauch, 1988). According to Eberhart and Russell the genotype with high mean,

Table 1. Stability parameters for different characters as per regression model of Eberhart & Russell (1966) in Italian millet [*Setaria italica* (L.) Beauv].

Genotypes	Protein content			Calcium Content			Carotene content		
	$\bar{X}$	b	$\bar{X}$	$\bar{X}$	$\bar{X}$	b	$\bar{X}$	b	S^2d
GS440	8.92	0.77	0.24	0.24	0.24	0.77	8.92	0.77	0.02
GS444	8.89	-0.17	0.32	0.32	0.32	-0.17	8.89	-0.17	0.02
GS445	9.00	1.95	0.19	0.19	0.19	1.95	9.00	1.95	0.08**
GS450	8.90	0.00	0.25	0.25	0.25	0.00	8.90	0.00	0.01
GS462	8.68	1.91	0.42	0.42	0.42	1.91	8.68	1.91	0.00
GS463	9.14	1.73	0.20	0.20	0.20	1.73	9.14	1.73	0.06*
GS465	8.63	2.26*	0.21	0.21	0.21	2.26*	8.63	2.26*	0.05
GS467	9.27	1.27*	0.33	0.33	0.33	1.27*	9.27	1.27*	-0.04
GS477	10.39	-0.35*	0.27	0.27	0.27	-0.35*	10.39	-0.35*	0.08
GS479	8.76	0.42	0.25	0.25	0.25	0.42	8.76	0.42	-0.03
GS480	9.42	-0.11	0.29	0.29	0.29	-0.11	9.42	-0.11	-0.04
GS482	8.79	1.33	0.21	0.21	0.21	1.33	8.79	1.33	-0.05
GS486	9.02	2.64	0.21	0.21	0.21	2.64	9.02	2.64	-0.04
GS487	9.45	0.15	0.21	0.21	0.21	0.15	9.45	0.15	0.05*
GS488	10.02	0.68	0.21	0.21	0.21	0.68	10.02	0.68	-0.03
GS489	9.29	1.32	0.23	0.23	0.23	1.32	9.29	1.32	-0.02
KDR	9.64	1.27	0.20	0.20	0.20	1.27	9.64	1.27	-0.01
NSR	9.36	0.51	0.21	0.21	0.21	0.51	9.36	0.51	-0.00
SRL	9.23	1.61	0.23	0.23	0.23	1.61	9.23	1.61	-0.02
PRD	9.51	0.78	0.32	0.32	0.32	0.78	9.51	0.78	-0.01
General mean	9.22		0.25	0.25	0.25		9.22		
S.Em ±	0.06	0.78	0.004	0.004	0.004	0.78	0.06	0.78	

unit regression coefficient and non-significant deviation from regression was considered to be stable over environments. According to AMMI model, when one interaction PCA axis accounts for most of G × E, a feature of AMMI model is the biplot procedure in which genotypes and environments taking mean values on abscissa and $IPCA_1$ scores on ordinate are plotted on the same diagram, facilitating inference about specific interactions as indicated by the sign and magnitude of $IPCA_1$ values of individual genotypes and environments (Sharma *et al.*,1998).

RESULTS AND DISCUSSION

The analysis of variance (Table1) indicated significant genotypic differences for all the characters. The environments also varied widely as evidenced from significant differences for environments and the environment (linear) component for all the characters. The genotype-environment interaction component also showed high significance for crude protein and calcium content. This indicated valid differences among genotypes for regression over environmental means. In general the genotype – environment (linear) component showed significance for all the characters except protein content thus indicating the importance of non-linear component in the genotype-environment interaction of Italian millet genotypes. This was further confirmed by the significance of S^2d in case of most of the genotypes for different characters especially protein content and calcium content. This requires careful interpretation of results based on non-significance of S^2d values (a parameter to measure stability) of genotypes for a particular character than the fluctuating linear component for

Figure 1. BiPlot (AMMI 1) for crude protein%.

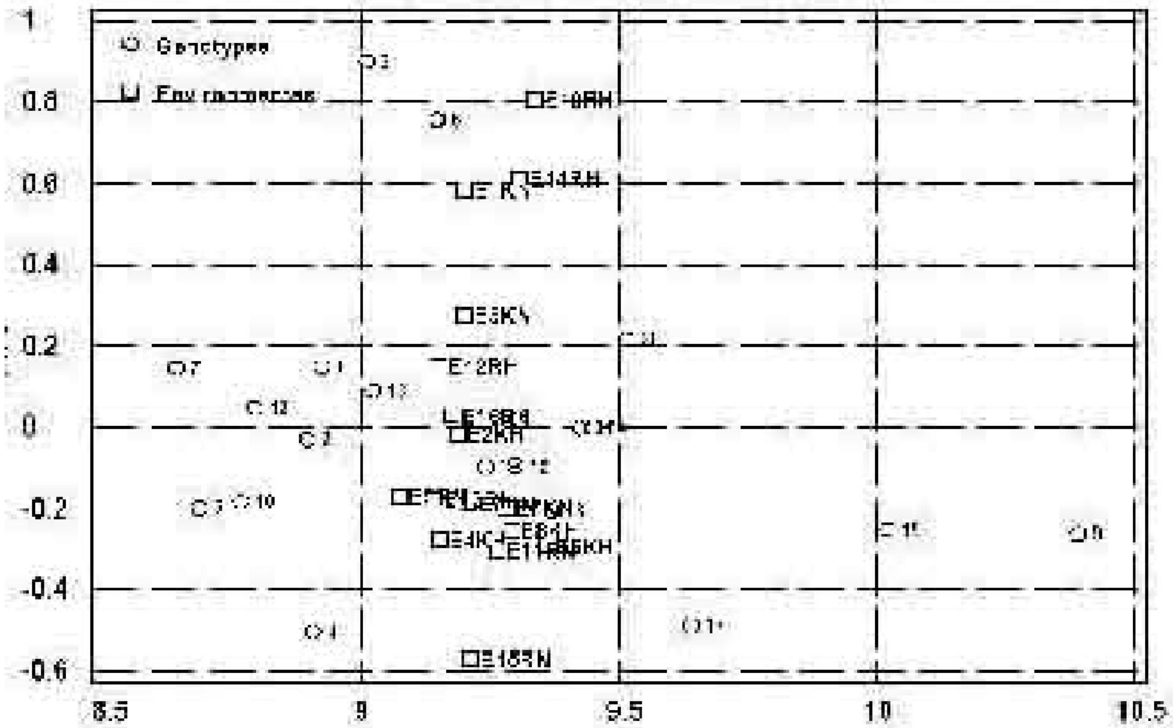


Figure 2 Interaction BIPLot (AMMI 2).

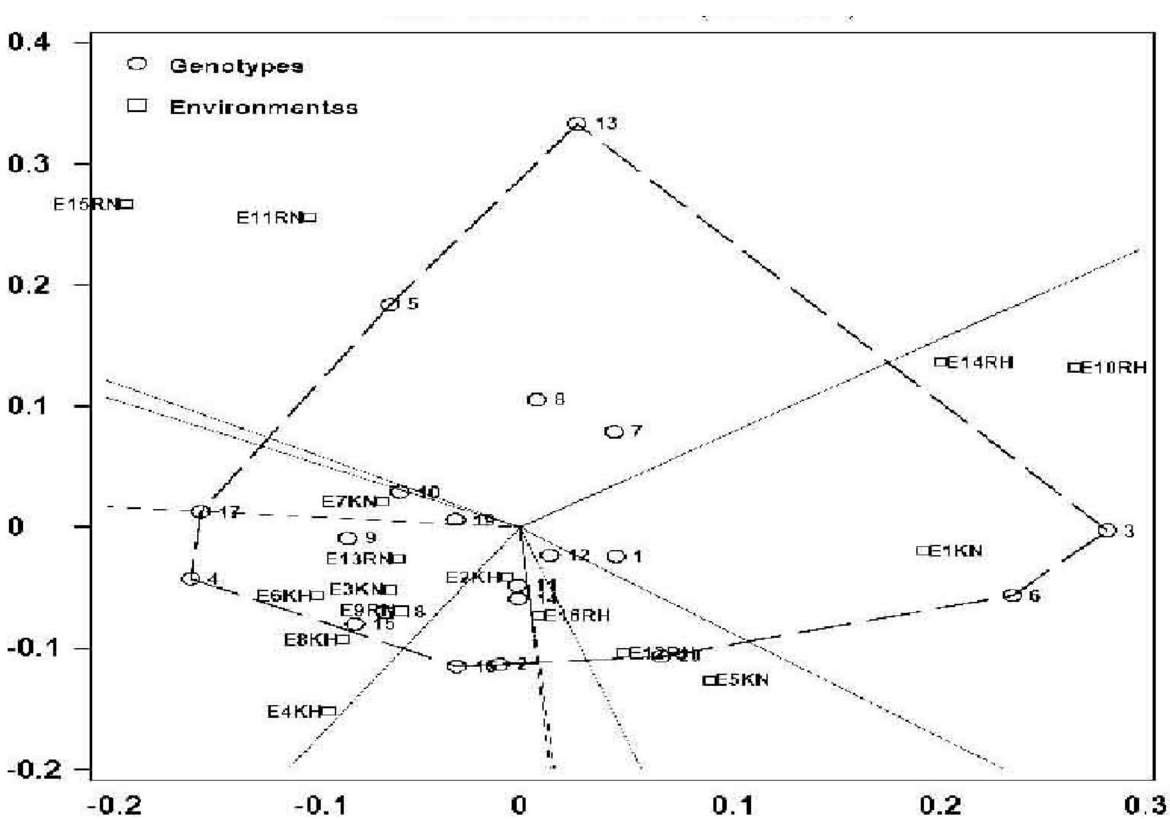


Figure 3. Biplot (AMMI 1) for calcium content mg/100g.

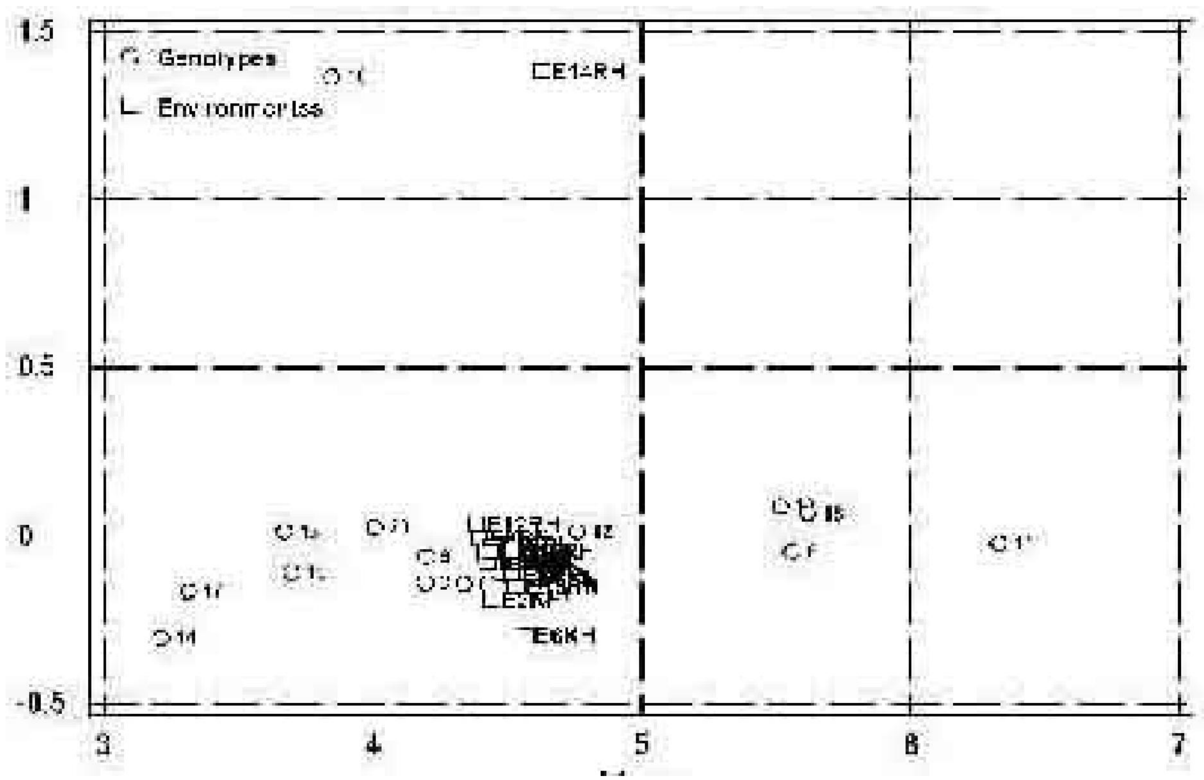


Figure 4. Interaction BiPlot (AMMI 2).

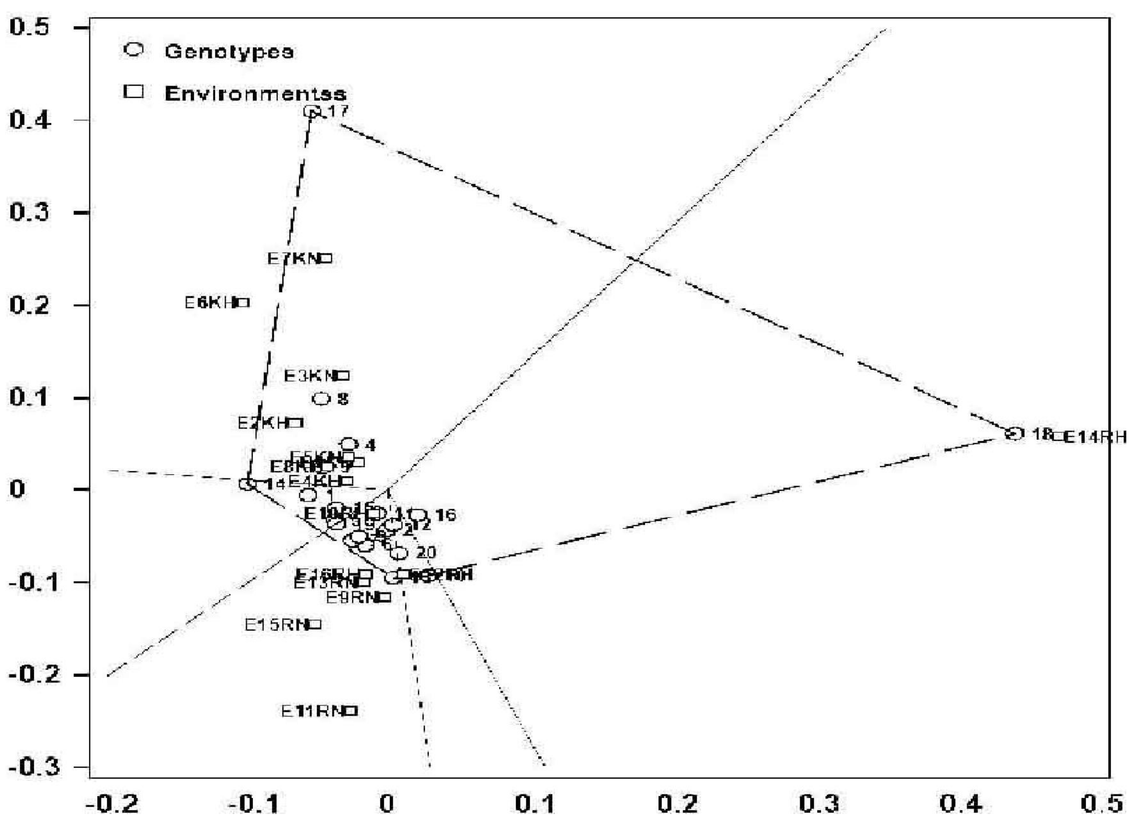


Figure 5. BiPlot (AMMI 1) for Carotene mg/100g

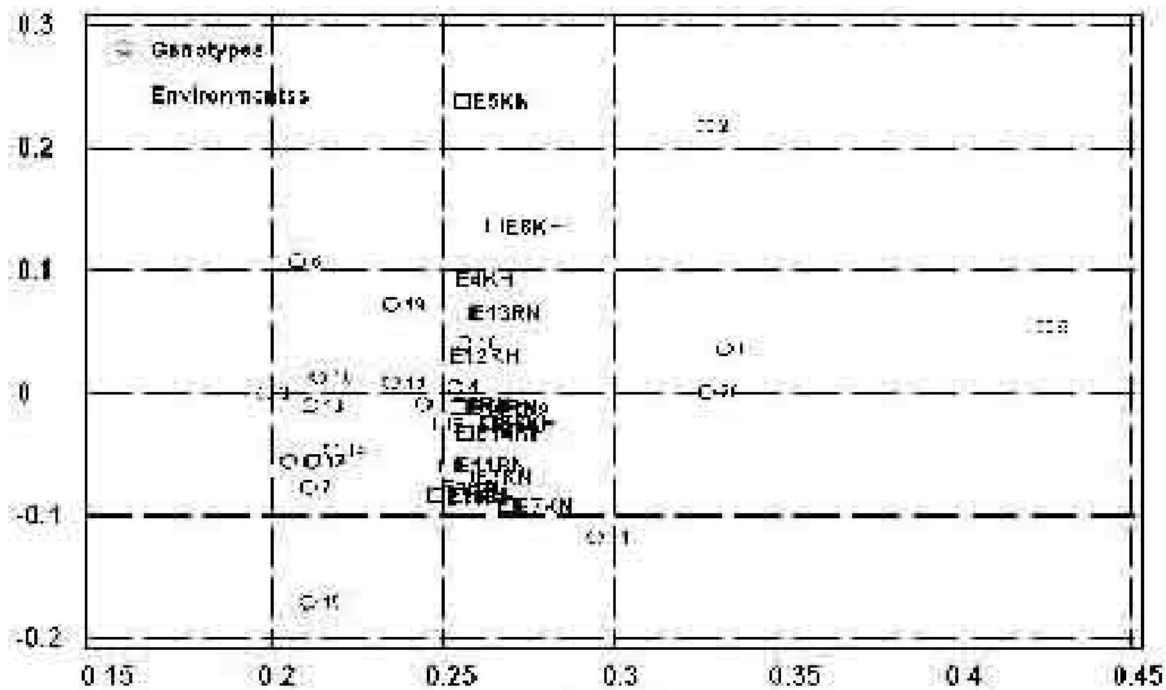
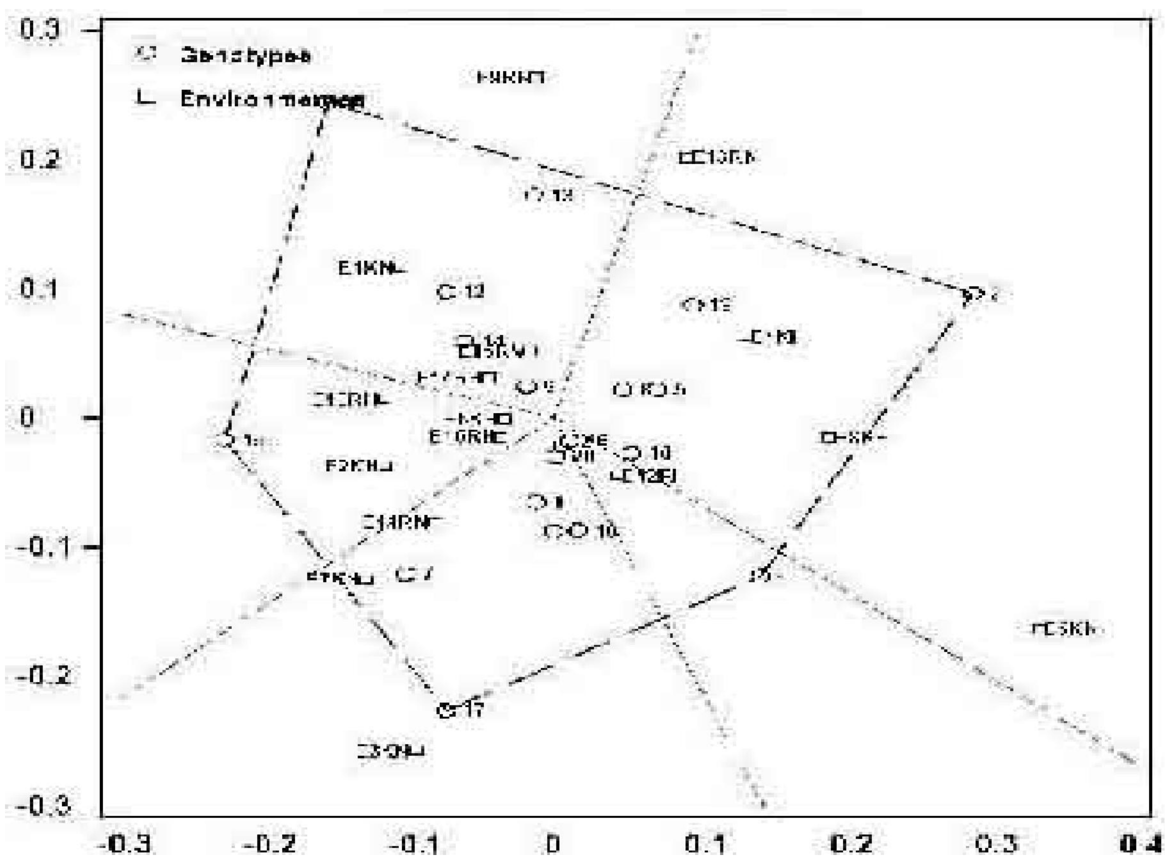


Figure 6. Interaction BiPlot (AMMI 2)



regression coefficient (a parameter which measures responsiveness). With expected desirable performance, the genotypes GS 488 and KDR (for protein content), GS 489, GS 463 and GS 479 (for calcium content) and GS 462 and GS 479 (for carotene content) may prove to be promising for cultivation (Table 2).

For protein content, AMMI analysis showed that genotypes and environments were significant. The genotype, environment and genotype x environment interaction accounting for 76.35%, 2.30% and 21.34% of the total variation respectively. ANOVA the G × E interaction was significant and was further partitioned into AMMI components with the contribution of 35.70%, 24.72%,18.02% and 11.57% to the total G × E interaction variance with 33, 31, 29 and 27 df respectively. According to AMMI1, genotypes like 11, 12 and 14 are more stable because their IPCA scores are near to zero. Genotype like 8 is generally adaptable to all environments and more stable. In AMMI2 biplot genotypes like 12 and 19 are stable across environments.

AMMI analysis for calcium content showed that genotypes and environments were significant. The genotype, environment and genotype x environment interaction accounting for 94.60%, 0.74% and 4.57% of the total variation, respectively. The ANOVA table indicated the G × E interaction was significant and was further partitioned into AMMI components with the contribution of 52.28% 24.28%, 9.69% and 6.07% to the total G × E interaction variance with 33, 31, 29 and 27 df respectively. According to AMMI1, most of the genotypes and environments having IPCA score near zero and their interactions are positive hence they are more responsive to all environments. Genotype 18 and environment XIV were with high $IPCA_1$ mean hence they have high interaction effect. By AMMI2 interaction biplot genotypes like 11, 15 and 12 were identified as most stable ones because they are situated close to the center of IPCA axis. Most of the genotypes are close to the center of IPCA axis. Environment XIV is most suited as it is indicated with high mean value of IPCA1 and low mean value of IPCA 2.

AMMI analysis for carotene content showed that genotypes and environments were significant. The genotype, environment and genotype x environment interaction accounting for 92.53%, 1.04% and 6.25% of the total variation, respectively. The ANOVA indicated the G × E interaction was significant and was further partitioned into AMMI components with the contribution of 32.85% 21.42%, 20.00% and 11.42% to the total G × E interaction variance with 33, 31, 29 and 27 df respectively. According to AMMI1, genotypes like 3, 4 and 20 are more stable because their IPCA scores are near to zero. By AMMI2 interaction biplot the genotypes like 4, 16 and 20 were identified as most stable ones because they are situated close to the center of IPCA axis. Environment V is most suited as it is indicated with high mean value of IPCA1 and low mean value of IPCA 2.

The ANOVA indicated non-significant G × E interaction for carotene content and ANOVA of (Eberhart and Russell, 1966) indicated non-significant G × E (linear) interaction for protein content, when tested against pooled deviation. As per AMMI analysis the $IPCA_1$ significantly contributed to all three characters protein content, calcium content and carotene content while $IPCA_2$ contributed significantly to G × E interaction for protein content, calcium content and carotene content. This brings out clearly the advantage of AMMI ANOVA in bringing out G × E interaction through $IPCA_1$ which gets combined with error in the other two ANOVA and points out the utility of AMMI models in studying the significant G × E interaction and identifying stable genotypes for characters which so undetected in the earlier analysis.

The results discussed here confirm that AMMI analysis with its biplot is a very useful tool in analyzing data. It explains comprehensively both the effects due to genotypes and environments and also their interaction patterns. ANOVA could explain only the genotypes and environments but not their interaction. AMMI partition the non-linear interaction component of genotype with environment interaction and also helps in having deeper insight into study of environmental contribution to G × E interaction as also pointed out by Zobel *et al*., (1988).

According to AMMI analysis the genotypes 2 and 11 (for protein conent); 9, most of the genotypes (for calcium content); 3, 4 and 20 (for carotene content); are more stable because they are having IPCA score near zero that is they show less interaction with environments. According to Eberhart and Russell (1966) the genotypes 15 and 17 (for protein content); 6, 16 and 10 (for calcium content); 5 and 10 (for carotene content) showed desirable performance.

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