



Stability for seed yield in ajwain based on Genotype Selection Index

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ABSTRACT

Ajwain is the second most important seed spice crop in Andhra Pradesh, India. It is grown as rainfed crop in vertisols. The crop is sown usually during July to September as a rainfed crop. There is a need for identifying suitable high yielding genotypes adaptable to rainfed vertisols. In view of this, fourteen genotypes were evaluated for their performance in rainfed vertisols for four years. The uniqueness of the rainfed environment which varies with year to year was taken as advantage and Additive Main Effect and Multiplicative Interaction (AMMI) analysis was used to understand the complex genotype x environment (GE) interactions. Further AMMI Stability Values and Genotype Selection Index (GSI) were worked out for the genotypes. Stability when assessed should be reliable. Genotype Selection Index (GSI) due to its nature of combining the estimated the stability measure and yield data, gave more useful information for selection and recommendation. The most desirable genotypes for selection of both stability and high grain yield were genotype 3 (LTa-26) followed by genotype 2 (LTa-25).

Key words: Adaptability, AMMI, PCA, Selection index, Stability.

INTRODUCTION

Ajwain is primarily grown as rainfed crop in vertisols. As of now very few varieties have been developed in this crop and there is immense scope for evolving genotypes suitable for rainfed situations. In rainfed situation, each season is unique therefore reliability of genotype performance across these environments is the key to identification of suitable genotypes under such conditions. A stable cultivar, with desired yield capacity is far desirable than a genotype that gives high yield only under certain environments but poorly adaptable. Stable performance and broad adaptation is most desirable in addition to high yielding potential of any variety under development. Although several methods are employed for GEI (Genotype x environment interaction) or phenotypic stability analysis, Additive Main Effect and Multiplicative Interaction (AMMI) model is desirable it facilitates simultaneous selection of varieties for yield and stability (Gauch, 1992). The model helps in establishing the relationship of genotypes, environment and their interaction (Gauch and Zobel, 1996).

The present study was therefore conducted to assess the nature and magnitude of G-E interaction, degree of correlation among some stability parameters of grain yield and to identify stable ajwain genotypes.

MATERIALS AND METHODS

Fourteen genotypes of Ajwain (*Trachyspermum ammi* (L.) Sprague ex Turrill) collected from Andhra Pradesh, India were evaluated for four consecutive years,

(2005-2009) under rainfed conditions of Horticultural Research Station, Lam. Description of the four environments are given in Table 1. The experimental design was randomized completely block design (RCBD) with three replications. The recommended package of practices for the area was adopted. A row to row spacing of 60 cm and plant to plant spacing of 20 cm was adopted. Observations on number of primary branches, number of secondary branches, number of umbels per plant, number of umbellets per plant, number of days to fifty percent flowering, duration to maturity and grain yield were recorded.

Statistical analysis: The four year yield data was subjected to pooled analysis using Crop Stat 7.2. Adaptability and stability of the genotypes was estimated using the Crop Stat 7.2. G x E biplots were generated to evaluate the genotypes simultaneously for yield and stability. ASV (AMMI Stability Value) values were estimated for both genotypes and environments. Further, GSV (Genotype Stability Index) values were estimated for genotypes.

RESULTS AND DISCUSSION

Since the environments are the years, the perusal of meteorological data of the study period indicated that environments the parameters which varied included the rainy days, total rainfall and the minimum rainfall. The minimum rainfall was received in the environment III whereas maximum was received in environment I. Minimum number of rainy days were recorded in environment IV. The differences in weather parameters of the test environments

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Table 1: Details of the environments evaluated.

Environment	Year	Date of sowing	Date of harvesting	Weather during the crop period (mean)					Sunshine hours	
				Rainfall (mm)	No. of rainy days	Temperature (°C)		Relative Humidity (%)		
						Max.	Min.	Max.		Min.
I	2005-06	10-08-06	03-03-06	231.9	19	31.3	19.4	86.5	68.9	6.6
II	2006-07	15-11-06	15-04-06	43.9	5	33.4	19.8	84.5	55.2	8.2
III	2007-08	17-11-07	25-04-08	21.0	3	31.2	20.8	88.7	49.0	4.5
IV	2008-09	18-11-09	28-04-09	67.2	2	34.0	19.4	88.0	54.0	5.2

projected a scenario for better discrimination of the genotypes.

The result of the pooled analysis over environments and AMMI analysis of grain yield is given in Table 2. The source of variation in the combined analysis were highly significant ($P < 0.01$) genotype (G), environment (E) and G x E interaction. Out of the total variance, environment alone accounted for larger variation of 46.7% followed by G x E interaction (GEI) (21.7%) and genotype (20.4%). This variability was primarily due to larger variation in rainfall, number of rainy days in each environment and high variation in mean sunshine hours among the environments. Further, the genotypes showed varied performance in response to the environments in which they were tested thus contributing larger variation in genotypes, and genotype and environment interaction. The mean yield across locations over four years revealed considerable changes in ranks among the genotypes, reflecting the presence of high G x E interactions (Baker, 1998). Pham and Kang (1988) viewed that as G x E interaction minimizes the usefulness of genotypes by confounding their yield performance, it is of great importance to study the adaptability and stability of the genotypes. Becker and Leon (1988) further indicated that estimation of stability could increase both reliability and heritability of important traits.

The larger variance component due to environment indicated that the test environments were reasonably different. The larger variance of genotypes and GEI indicated that the test varieties differed in their performance substantially over environments and there was a close association of performance of genotype to environments. The magnitude of the GE interaction was almost equivalent to that of genotypes (1.06 times), showing that there were varied differences in the genotypic response across environments. Overall, AMMI model contained 90.3% of the treatment SS, while the residual contained 9.7%. These results indicate that the AMMI model fit the data well and justifies the use of AMMI.

The mean squares of genotypes, environments and genotype x environments were all highly significant indicated that significant differences existed among genotypes, the environments (seasons in the present study) had exerted significant influence on the expression of genotypes. Significant G x E mean squares indicated that the expression of genotypic performance was non linear across the environment, in other words was unpredictable. Such observations are common in rainfed farming situations, with considerable year to year variations in the performance of the genotypes. This signifies the fact that the breeders need to develop stable varieties that can perform reasonably well under a range of conditions to avoid risk in the production systems. Especially in marginal environments, farmers opine that yield stability is the most desired trait to overcome crop

Table 2: The combined analysis of variance and interaction principal components in AMMI for grain yield.

Source	df	SS	MS	F-value	% in Variance	
					Total	% G X E
Environment (E)	3	7397320.00	2465770.0	145.13**	46.7	
Genotype (G)	13	3224500.00	248038.00	14.60**	20.4	
G x E	39	3440200.00	88210.3	5.19**	21.7	
IPCA 1	15	2221662.2	148110.8	8.7**	14.4	64.6
IPCA 2	13	1110686.7	85437.4	5.3**	7.0	32.3
IPCA 3	11	107851.1	9804.6	0.6ns	0.7	3.1
Error	104	1766980.00	16990.2		11.2	
Total	167	15829000.00	94784.7			

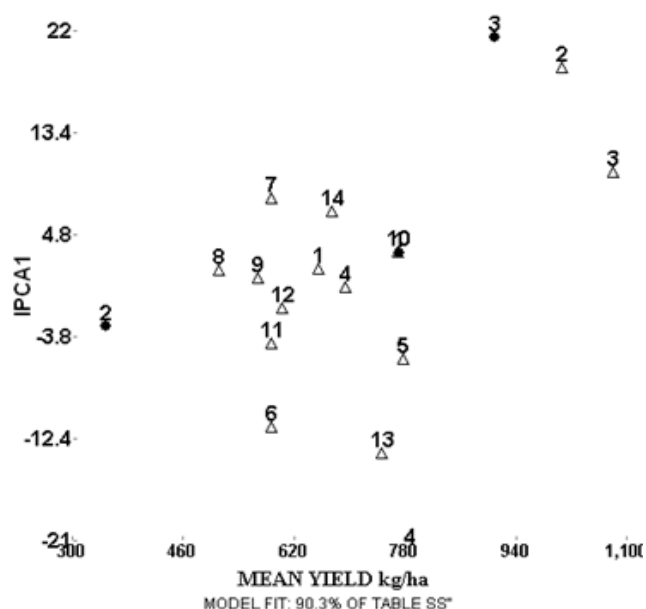
** significant at $p=0.01\%$, CV=19.3%, df=degrees of freedom, SS= Sum of squares, MS= Mean square

failure. (Ceccarelli, 1994 and Piepho, 1998). Further, Romagosa and Fox (1993) indicated that while developing varieties for variable environments, testing of widely adapted genotypes covering representative samples of special and temporal variations would achieve the desired breeding outcome. Most of the GxE variation was explained by IPCA I scores.

IPCA qualitative and quantitative interactions: The genotype and environment scores for IPCA were both positive and negative values. (Table 3 and 4) representing a disproportionate genotype response (Yan and Hunt, 2001), thus forming the principle source of variation for any crossover interaction. Conversely, scores with the same sign or near zero represent a non-crossover G x E interaction or a proportionate genotype response. The IPCA scores of a genotype in the AMMI analysis were reported by Gauch and Zobel (1996) as indication of the stability of genotypes are across their testing environments (Yau, 1995).

AMMI Stability Value (ASV): The distance from zero in a two dimensional scattergram of IPCA1 (interaction principal component analysis axis 1) scores against IPCA2 scores is a fair indication of stability (Purchase, 1997; Adugna and Labuschagne, 2002). The genotypes with high ASV were most unstable and vice-versa. The ASV values indicated that the genotypes LTa-35, LTa-24 and LTa-22 were most stable across environments. And the genotypes, LTa-25, LTa-36 and LTa-29 performed superiorly in certain environments.

G x E bi-plot analysis : Biplot analysis and ordination techniques revealed high significant differences for IPCA1, IPCA2 and IPCA3. The noise estimated in the interaction pattern is only 9.2% indicating that the model used is fit for evaluating the genotypes (Gauch and Zobel, 1988; Gauch, 1992). The results of PCA of GEI are presented in Figure 1 and 2 as per Cooper and Delacy (1994). Biplot analysis revealed that the environments 2, 3 and 4 had the greatest effect in GE interaction. Biplot of IPCA1 and IPCA2 (Figure 1) covers 96.6 % of GE interaction. The position and perpendicular projection of genotypic points onto an environmental vector can be used to identify a genotype or genotypes having specific adaptation in that environment(s)

**Fig 1:** Biplot of mean seed yield and IPCA 1 scores.

(Yan *et al.*, 2000). Genotype farther from the center of biplot show specific adaptation. Several genotypes had shown specific adaptations to specific environments.

The genotypes LTa-25 and LTa-26 though had high mean yields, were having adaptability to the environment 3. The genotypes LTa-36 and LTa-29 were better adapted to the environment 2. Genotypes toward the center of biplot have zero interaction, therefore have general adaptation with different mean grain yield. Genotypes 1 (LTa-24), 12 (LTa-35), and 9 (LTa-32) are located in this category. However, their mean yields are lower than the check variety Lam Selection-1. However, genotype 3 (LTa-26) and 2 (LTa-25) has highest mean yield and relatively stable over the four environments, presents a better selection option for the breeder.

The simultaneous overview of stability and yield helps quick and precise interpretation and selection of genotypes (Wade *et al.*, 1999; Alagarswamy and Chandra, 1998; Farshadfar and Sutka, 2003). The environment vectors

Table 3: First, second and third IPCA scores, ASV and GSI of genotypes investigated

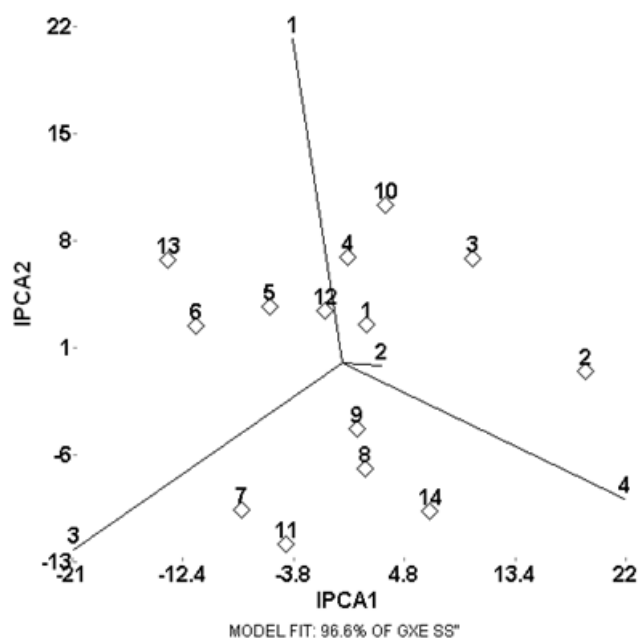
Genotype	Yield		AMMI Model			ASV	GSI
	kg ha ⁻¹	Rank	IPCA ₁	IPAC ₂	IPCA ₃		
LTa-24	655	7	1.89	2.53	-3.68	4.54	15
LTa-25	1007	2	18.87	-0.56	4.5	37.75	5
LTa-26	1080	1	10.13	6.79	4.31	21.37	3
LTa-27	693	6	0.35	6.88	-1.77	6.92	14
LTa-28	778	3	-5.66	3.67	4.9	11.89	8
LTa-29	587	12	-11.41	2.43	0.85	22.96	21
LTa-30	588	10	-7.89	-9.62	0.46	18.48	19
LTa-31	512	14	1.78	-6.92	-7.34	7.78	26
LTa-32	567	13	1.13	-4.27	-2.44	4.83	24
LTa-33	770	4	3.37	10.32	-6.74	12.32	10
LTa-34	587	11	-4.39	-11.79	1.09	14.7	21
LTa-35	603	9	-1.33	3.42	-0.73	4.34	19
LTa-36	747	5	-13.59	6.78	4.04	28.02	11
LS-1	651	8	6.76	-9.66	2.55	16.62	16

Table 4: First, second and third IPCA scores and ASV of environments tested

Environment	IPCA1	IPAC2	IPCA3	ASV
1	3.21	21.18	3.95	22.13
2	-2.91	-0.18	-12.48	5.82
3	21.47	-12.16	3.16	44.64
4	-21.78	-8.84	5.37	44.45

covered a wide range of the Euclidean space, indicating that the nine environments of study represented a wide range of environments (Table 2).

Genotype Selection Index (GSI): Usually, stability is not the primary selection criteria but the yield. The genotypes with yield superiority may not have desired level stability (Mohammadi *et al.*, 2007). Hence, Genotype Selection Index as proposed by Kang (1991, 1993) are used here to interpret the data of the genotypes. de Oliveira (2014) used selection index to discriminate advantageous genotypes in Maize and expressed importance of selection index. ASV takes into account both IPCA1 and IPCA2 that justify most of the variation of GE interaction, therefore the rank of ASV and mean grain yield (R) are incorporated in a single selection index namely Genotype Selection Index (GSI). The least GSI is considered as the most stable with high grain yield.

**Fig 2:** AMMI2 genotype x environment biplot

Based on the GSI the most desirable genotype for selection of both stability and high grain yield is genotype 3 (LTa-26) followed by genotype 2 (LTa-25).

REFERENCES

- Adugna, W. and Labuschagne, M.T. (2002). Genotype- environment interactions and phenotypic stability analysis on linseed in Ethiopia. *Plant Breeding*. **121**: 66-71.
- Alagarswamy, G. and Chandra, S. (1998). Parttern analysis of international sorghum multi-environment trials for grain-yield adaptation. *Theoretical and Applied Genetics*. **96**: 397-405.
- Baker, R.J. (1998). Tests for cross over genotype-environment interactions. *Canadian Journal of Plant Science*. **68**: 405-410.
- Becker, H.C. and Leon, J. (1988). Stability analysis in plant breeding. *Plant Breeding*. **101**: 1- 23.
- Ceccarelli, S. (1994). Specific adaptation and breeding for marginal conditions. *Euphytica*. **77**: 205-219.

- Cooper, M. and Delacy, I.H. (1994). Relationships among analytic methods used to study genotypic variation and genotype-by-environment interaction in plant breeding multi-environment trials. *Theoretical and Applied Genetics*. **88**: 561-572.
- de Oliveira, R.L., Von Pinho, R.G., Ferreira, D.F., Pires, L.P.M. and Melo, W.M.C. (2014). Selection index in the study of adaptability and stability in maize. *The Scientific World Journal*. **2014**:1-6.
- Farshadfar, E. and Sutka, J. (2003). Locating QTLs controlling adaptation in wheat using AMMI model. *Cereal Research Communications*. **31**: 249-254.
- Farshadfar, E. (2008). Incorporation of AMMI stability value and grain yield in a single non-parametric index (GSI) in bread wheat. *Pakistan Journal of biological sciences*. **11(14)**: 1791. -1796.
- Gauch, H.G. (1992). Statistical analysis of regional yield trials: AMMI analysis of factorial designs. Elsevier, Amsterdam, the Netherlands; Chinese edition 2001, China National Rice Research Institute, Hangzhou, China.
- Gauch, H.G. and Zobel, R.W. (1996). AMMI analysis of yield trials. In: Genotype by Environment Interaction (Eds. M.S. Kang, and H.G. Zobel Jr),CRC Press, Boca Raton. pp. 85-120.
- Gauch, H.G., and R.W. Zobel. (1988). Predictive and postdictive success of statistical analyses of yield trials. *Theoretical and Applied Genetics*. **76**: 1-10.
- Kang, M.S. (1991). Modified rank-sum for selecting high-yielding, stable corn genotypes. *Cereal Research Communications*. **19**: 361-346.
- Kang, M.S. (1993). Simultaneous selection for yield and stability in crop performance trials. Consequences for growers. *Agronomy Journal*. **85**: 754-757.
- Mohammadi, R., R. Haghparast, M. Aghaee and Rostaei, M. (2007). Biplot analysis of multi-environment trials on bread wheat yield under rainfed condition in Iran. *Crop Research*. **33**: 170-178.
- Pham, H.N. and Kang, M.S. (1988). Interrelationships among repeatability of several stability statistics estimated from international maize trials. *Crop Science*. **28**: 925-928.
- Piepho, H.P. (1998). Methods for comparing the yield stability of cropping systems. *Journal of Agronomy and Crop Science*. **180(4)**: 193-213.
- Purchase J.L. (1997). Parametric analysis to describe genotype x environment interaction and yield stability in winter wheat, (Ph.D. Thesis), University of Free State, Bloemfontein.
- Romagosa, I. and Fox, P.N. (1993). Genotype-Environment Interaction and Adaptation. In: Plant Breeding: Principles and prospects (Eds. M.D. Haward, N.O. Bosemark, and I. Romagosa), Chapman and Hall, London. pp. 374-390.
- Truberg, M. and Huhn, H.G. (2000). Contribution to the analysis of Genotype Environment Interactions: Comparison of Different parametric and Non-parametric test for interactions with emphasis on crossover interactions. *Journal of Agronomy and Crop Science*. **185**: 267-274.
- Wade, L.J., McLaren, C.G., Quintana, L., Harnpichitvitaya, D., Rajatasereekul, S., Sarawgi, A.K., Kumar, A., Ahmed, H.U., Singh, A.K., Rodriguez, R. and Siopongco, J. (1999). Genotype by environment interactions across diverse rainfed lowland rice environments. *Field Crops Research*. **64(1)**: pp.35-50.
- Yan, W., Hunt, L.A., Sheng, Q. and Szlavniks, Z. (2000). Cultivar evaluation and mega-environment investigation based on the GGE biplot. *Crop Science*. **40**: 597-605.
- Yan, W. and Hunt, L.A. (2001). Interpretation of genotype x environment interaction for winter wheat yield in Ontario. *Crop Science*. **41**:19-25.
- Yau, S.K. (1995). Regression and AMMI analysis of genotype-environment interactions: an Empirical comparison. *Agronomy Journal*. **87**: 121-126.