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Multivariate Analysisfor Umbel per plant in Land races of Coriander(*Coriandrum sativum* L.)

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ABSTRACT

Twenty five land races from Madhya Pradesh and ten germplasm of coriander were evaluated in four environments to assess umbel per plant using multivariate analysis. Mean sum of squares due to genotypes, environments and GEI were highly significant for umbels per plant. Variation in GEI was mainly due to heterogeneity. PCA 1 and PCA 2 captures the 99.42% of interaction sum of squares hence, these two principal component axes were the best predictive. The potential environment the potential environments E_3 (high fertility, 2009-10) bearing lowest interaction effect while, least potential environments E_2 (low fertility, 2008-09) exhibited high PCA scores. The biplot of genotype, environment and IPCA 1 showed three groups. One group exhibited the similar main effects (mean umbels per plant) to the grand mean. The second group showed high interaction effect varied in direction while third group bear the low interaction effect. AMMI Stability Values (ASV), ranging from 7.444 to 31.099 was lowest in RVC 8 followed by RVC 4, RVC 11, RVC 21, RVC 9 and RVC 3 whereas, it was noted maximum in RVC 19 followed by Moroccan, CS 193, Simpo S 33 and G 5363. The genotypes exhibiting low IPCA scores and ASVnamely, RVC 8,RVC 4,RVC 11,RVC 21, RVC 19 and RVC 25 showed wider adaptability for umbels per plant while, RVC 19, Moroccan, CS 193, Simpo S 33 and G 5363 exhibiting specific adaptability towards environmental conditions. These genotypes can be utilized in breeding programmes to transfer the adaptability genes for umbel per plant into high yielding genetic back ground in coriander.

Introduction

Coriander (*Coriandrum sativum* L.) is an annual herb and its all plant parts are edible but, fresh leaves and dried seeds are most commonly used in cooking of vegetables, fish and meat. Most of the coriander is consumed in form of curry powder. The crop is grown in Morocco, Romania, Mexico, Argentina, China, Bangladesh, Bulgaria, Canada, Egypt, India, Indonesia, Nigeria, Poland, Syria, USA and Russia. In India, Coriander is grown in about 3.62 lakh hectares with annual production of about 2.88 lakh tonnes. Rajasthan and Madhya Pradesh contribute about 71.26 per cent to national coriander basket from an area share of about 67.48 per cent. Madhya Pradesh ranks second in area and production of coriander in the country and produces about 0.50 lakh tones from 1.17 lakh hectares area. The productivity of coriander in the state is very low (428kg/ha) as compared to national average productivity (795kg/ha). Prevalence of land in the cultivation of coriander is the major reasons of low productivity.

Seed yield is a complex trait, governed by polygene and highly influenced by environmental fluctuations. On the other hand, yield traits are governed by less number of genes and least susceptible to environmental variations. Umbel per plant has identified as major yield component in coriander through path coefficient analysis (Sharma et al, 1987; Peter et al, 1989and Bhandari and Gupta, 1991). However, meagre information is available on genotype – environment interaction (GEI) of this trait. Hence, an attempt was made in this study to collect the landraces from coriander growing districts of Madhya Pradesh. The collected land races and germplasm were quantified for umbels per plant using multivariate analysis so that economic gene pool can identify after knowing the extent of GEI for sound and effective improvement programme in coriander.

Materials and Methods

The material of this study comprised twenty five land races of coriander, collected from Vidisha, Guna, Rajgarh, Sehore, Bhopal and Morena districts of Madhya Pradesh and ten genotypes, collected from different research stations in the country. These genotypeswere evaluated in four environments created by adjusting fertility status of the soil in two subsequent years of 2008-09 and 2009 -10. The experiment was laid out in randomized complete block design with three replications in each environment. Each genotype was grown in 4 row plots of 4.0 m length with row to row distance of 25 cm on November 07, 2008 and November 11, 2009 during 2008 - 09 and 2009 -10, respectively. The plant to plant distance was maintained at 10 cm in all the environments. Fertilizer was applied as basal @ 60:30:15 kg NPK/ha and 40:20:10 kg NPK/ha in high and low fertility conditions of both the years, respectively. The full doses of phosphorus and potassium along with half dose of nitrogen was given as basal at the time of sowing while, rest of the nitrogen was top dressed during the crop growth. The fertilizers were applied as per environment while, experiment was laid out under rainfed condition. Ten competitive plants were randomly selected and tagged for recording observations on umbels per plant in each genotype, each replication and each environment. Principal component analysis (Gauch, 1988 and Zobel et al., 1988) was carried out using statistical software IRRISTAT. AMMI‟s stability value (ASV) was calculated in order to rank genotypes in terms of stability using the formula suggested by Purchas (1997).

Results and Discussion

The mean squares due to genotypes and environments were highly significant for umbels per plant (Table 1). It indicates the existence of significant differences among genotypes as well as environments. The percent contribution of genotypes was highest for this character (97.90%) indicating that it was least influenced by the environmental variation having environmental contribution of 1.70%. GEI was also highly significant but it was mainly due to heterogeneity. It means cultural irregularities were responsible for environmental variation in the present material. Partitioning of GEI into PCA axis showed highest contribution of PCA 1 (99.90%) for this character (Table 1). PCA 1 and PCA 2 captures the 99.42% of interaction sum of squares hence, only these two principal component axes of interaction were the best predictive model (Zobel et al., 1988). Thus, the interaction of 35 genotypes with 4 environments was the best predicted by the first two principal components of genotypes and environments (Gauch and Zobel, 1989 and Yan and Rajcan, 2002).

Average number of umbels per plant was found highest (98.65) in E3 (high fertility, 2009-10) with least interaction effects having negatives estimates of PCA 1 and PCA 2 (Table 2). The lowest number of umbels per plant were recorded in E_2 (lowfertility, 2008-09) with least interaction effect with minimum estimates of PCA (0.778 and 2.526)

Umbels per plant over environments, first and second interaction principal component scores and AMMI stability values for 35 genotypes are presented in Table 3. RVC 19 bears maximum number of umbels per plant followed by RVC 26, JD 1-1, RVC 10, JD 1 and RVC 25. Minimum umbels per plant bearing genotypes were RCR 41, C 5363, Simpo S 33, CS 193, PMIN 5 and UD 20. IPCA score, ranging from - 0.840 to 0.887 were in general, low in magnitude. It indicates that majority of genotypes of present study were stable in phenotypic expression of umbels per plant in different environments. Moroccan, CS 193, Simpo S 33, PMIN 5, RCR 41 and G 5363 showed negative and minimum estimates of IPCA 1 score while, RVC 19, RVC 26, RVC 10, RVC 18, RVC 5 and RVC 24 exhibited positive and comparatively maximum score of this parameter. Similarly, the magnitude of IPCA 2 was also low and varied from – 0.536 to 0.592.

Table 1 Analysis of variance for umbel per plant in coriander using multivariate analysis*

Source of variation	df	Mean sum of square for umbel per plant	Probability
Environments	3	75.442 [1.70]	P < 0.01
Genotypes	34	389.218 [97.90]	P < 0.01
G x E Interaction	102	0.580 [0.40]	P < 0.01
Heterogeneity	34	1.513 [86.90]	P < 0.01
Deviations	68	0.114 [13.10]	
PCA component 1	36	135.829 [99.30]	
PCA component 2	34	0.115 [0.10]	
PCA component 3	32	0.361 [0.00]	
PCA component 4	30	0.202 [0.00]	
Residuals after 2	70	0.563	
Pooled error	139	0.160	

*Figures in parenthesis are the per cent contribution

Table 2 Mean, IPCA 1 and IPCA 2 for umbel per plant ineach environment in coriander

Environments	UPP[1]	IPCA 1	IPCA 2
E 1 (High fertility, 2008-0	92.67	-0.232	3.281
E 2 (Low fertility, 2008-09)	77.25	0.788	2.526
E 3 (High fertility, 2009-10)	98.65	-6.108	-2.659
E4 (Low fertility, 2009-10)	85.61	5.552	-3.148

[1]UPP=Umbel per plant

AMMI biplot showed environment variability in both main effect and interaction effects (Fig.1) for umbel per plant. However, the potential environments were E_3bearing minimum interaction effect while, least potential environments E_2exhibited high PCA scores. The biplot of genotype, environment and IPCA 1 for umbel per plant (Fig.2) showed three groups. One group exhibited the similar main effects (mean umbels per plant) to the grand mean. The second group showed high interaction effect varied in direction while third group bear the low interaction effect. The greater IPCA score with whatever direction, indicates the most specifically adaption of genotypes to certain environments (Zobel et al., 1988). Thus, RVC 19 having highest number of umbel per plant and maximum interaction effect was found responsive to high fertility conditions. On the other hand, Moroccan, CS 193, Simpo S 33, PMIN 5, RCR 41 and G 5363 bearing minimum number of umbels per plant and interaction component were responsive to low fertile environments. Genotypes RVC 8, RVC 11, RVC 4, RVC 21, RVC 9, RVC 3, RVC 13, RVC 15, RVC 18, RVC 10,RVC 26,RVC 5, RVC 22, RVC 23, JD 1-1 and JD 1 possess average number of umbels per plant and average response towards environmental variation. AMMI stability values (ASV) ranged from 7.444 to 31.099 among the tested genotypes (Table 3). Genotype RVC 8 was found most stable having lowest estimate of ASV followed by RVC 4, RVC 11, RVC 21, RVC 9 and RVC

3 whereas, RVC 19 followed by Moroccan, CS 193, Simpo S 33 and G 5363 were least stable for this trait having the maximum estimates. These genotypes appeared as promising for incorporation in breeding programme to transfer more number of umbels per plant in high yielding genetic background with yield stability in coriander.

A comparison of results obtained in principal component analysis and AMMI stability value indicates more or less similar adaptability behaviour of genotypes (Table 3). The variation in result in different methods is due to non-fulfilment of assumption of different procedures. However, AMMI analysis provides the information on main effects as well as interaction effects and depiction of PCA score gives better understanding of the pattern of genotype – environment interaction. The sum of squares due to PCAs are also used for the computation of AMMI stability values for better identification of the adaptability behaviour of genotypes hence, additive main effects and multiplicative interaction (AMMI) model is most appropriate for the analysis of G x E interactions in coriander (Zobel et al., 1988; Berger et al., 2006 and Sadeghi et al., 2011).

It can be concluded from this study using multivariate analysis that genotypes were mostly related but responded differently to differences in environments as portion of environmental variance and G x E interaction hence, one can rely more on suitability of the environment and crop management conditions to attain the high yield in coriander. The genotypes exhibiting low IPCA scores and ASVnamely, RVC 8, RVC 4,RVC 11,RVC 21, RVC 19 and RVC 25 showed wider adaptability for umbels per plant while, RVC 19, Moroccan, CS 193, Simpo S 33 and G 5363 exhibiting specific adaptability towards environmental conditions. These genotypes can be utilized in breeding programmes to transfer the adaptability genes for umbel per plant into high yielding genetic back ground in coriander.

Table 3 Umbels per plant over environments, Ist and IInd interaction principal component and AMMI stability values for 35 genotypes in coriander

S. No.	Genotypes	Umbels per plant		First IPCA	Second IPCA	ASV	
		Mean	Rank			Value	Rank
1	RVC 1	17.92	28	-0.144	0.053	13.039	10
2	RVC 2	22.24	24	-0.233	-0.423	16.602	18
3	RVC 3	29.29	13	0.106	0.099	11.194	6
4	RVC 4	27.37	20	0.067	-0.199	8.885	2
5	RVC 5	30.71	10	0.535	0.152	25.141	24
6	Panipat local	19.60	27	-0.180	0.028	14.580	15
7	G C 3	28.08	15	0.232	-0.018	16.553	17
8	RVC 8	29.63	12	0.047	-0.106	7.444	1
9	RVC 9	27.53	19	-0.087	0.055	10.134	5
10	RVC 10	34.97	4	0.671	0.014	28.152	26
11	RVC 11	27.71	17	-0.078	-0.112	9.604	3
12	RVC 12	20.78	25	0.172	-0.328	14.242	13
13	RVC 13	27.97	16	0.114	0.592	11.629	7
14	RVC 14	27.58	18	0.154	-0.132	13.482	11
15	RVC 15	28.22	14	0.321	-0.169	19.467	21
16	RVC 16	23.57	23	0.174	-0.417	14.321	14
17	RVC 17	26.07	21	0.164	0.082	13.921	12
18	RVC 18	30.05	11	0.579	0.299	26.157	25
19	RVC 19	46.04	1	0.887	0.472	32.375	35
20	RVC 20	19.75	26	-0.217	-0.097	16.013	16
21	RVC 21	25.36	22	-0.081	-0.057	9.784	4
22	RVC 22	34.48	7	0.319	-0.337	19.402	20
23	RVC 23	31.72	9	-0.237	-0.247	16.738	19
24	RVC 24	31.80	8	0.425	-0.536	22.393	22
25	RVC 25	34.62	6	0.136	0.108	12.678	9
26	RVC 26	36.23	2	0.720	0.217	29.165	31
27	JD 1 (Check)	34.67	5	0.131	0.093	12.443	8
28	JD 1-1	35.18	3	0.474	0.101	23.663	23
29	CS 193	7.32	32	-0.819	0.198	31.099	33
30	Moroccan	14.38	29	-0.840	0.118	31.496	34
31	RCR 41	6.32	35	-0.697	0.114	28.690	28
32	UD 20	10.30	30	-0.676	0.100	28.255	27
33	Simpo S 33	7.27	33	-0.733	0.104	29.422	32
34	PMIN 5	10.29	31	-0.705	0.114	28.854	30
35	G 5363	6.58	34	-0.697	0.076	28.691	2

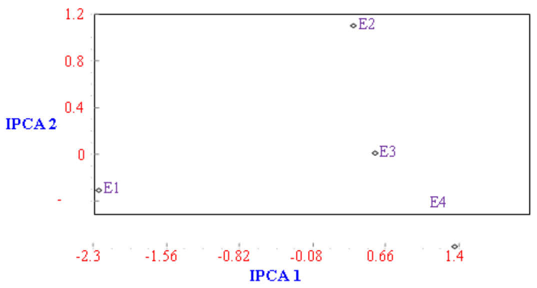

Fig 1 Projection of environments on first two principal components of G x E interaction for umbellate per umbel in coriander

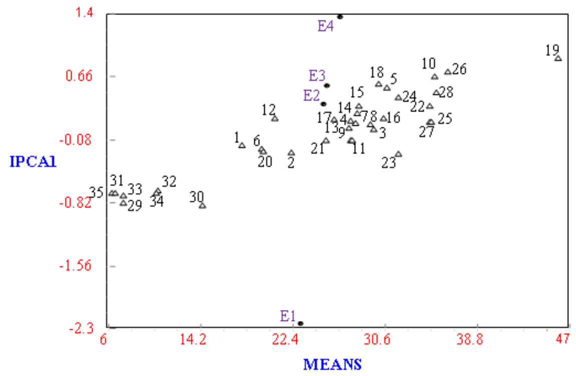

Fig 2 Biplot of genotypes, environments and PCA 1 for umbels per plant in coriander over environments

1 -RVC 1,2-RVC 2,3-RVC 3,4-RVC 4,5-RVC 5 ,6-Panipat local,7-G C 3,8-RVC 8, 9-RVC 9,10-RVC 10,11-RVC 11,12-RVC 12,13-RVC 13, 14-RVC 14,15-RVC 15,16-RVC 16,17-RVC 17,18-RVC 18,19-RVC 19,20-RVC 20,21-RVC 21,22-RVC 22,23-RVC 23,24-RVC 24,25-RVC 25,26-RVC 26,27-JD 1 (Check),28-JD 1-1,29-CS 193,30-Moroccan,31-RCR 41,32-UD 20,33-Simpo S 33, 34-PMIN 5, 35-G 5363

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