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Stability analysis for seed yield, its contributing traits and oil content in coriander (*Coriandrum sativum* L.)

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Abstract

Twenty genetically different genotypes of coriander were evaluated for their stability with respect to their seed yield, its contributing traits and oil content. Environments differed significantly as revealed by significant mean square due to environment (linear) for all the traits studied. The genotype x environment interactions was found significant for days to flowering, plant height, 1000 seed weight, harvest index and oil content. Whereas non-significant mean square genotype x environment interaction for remaining traits showed linear response of genotypes to varying environments. Both linear and non-linear interactions were significant for plant height, 1000 seed weight, harvest index and oil content, whereas for seed yield only linear component was significant. The genotypes with good yield potential, average plant height and medium maturity were G.Cori-1, RCr-20, UD-262, RCr-446, UD-744, CS-2, RCr-41 and G.Cori-2 suited for favourable environment, while Patan mandi-1 and UD-447 with regression coefficient (bi) < 1.0 could be suitable for low yielding environment.

Key words: *Coriandrum sativum*, genotype environment interaction, genetic stability

Coriander (*Coriandrum sativum* L.) is usually grown on marginal lands. Its production and productivity fluctuate every year due to various environmental factors. Genetic differences do exist among varieties for yield stability. The factors responsible for such differences need to be specially determined and utilized in breeding programme. Characterization of genotype-environment interaction in coriander would be immensely helpful if estimated over prevalent agricultural practices. This would lead to successful evaluation and development of phenotypically stable and superior varieties which are usually sought for commercial production. Keeping this in view, the present investigation was carried out to develop stable genotypes for the Southern Rajasthan, a non-traditional coriander growing zone.

Twenty genetically diverse genotypes of coriander were evaluated in three environments viz. E1 (early, 23rd Oct.), E2 (optimum, 4th Nov.) and E3 (late, 16th Nov.) at Udaipur during *rabi* season of 2000-2001, in a randomized block design with three replications. The number of rows per entry was two. The row length was three meters with row to row spacing of 30 cm and plant to plant 10 cm. Observations were recorded on ten randomly selected plants per entry in each treatment and replication for plant height, number of primary branches plant^{-1}, number of umbels plant^{-1}, number of umbellets umbel^{-1}, number of seeds umbel^{-1}, 1000 seeds weight, seed yield plant^{-1} and harvest index whereas for days to flowering, days to maturity and oil content, entire population was taken into consideration. The stability analysis was done following Eberhart & Russell (1966). The essential oil content in seeds was estimated by steam distillation method (A.O.A.C. 1995).

The analysis of variance for individual as well as pooled environments showed that mean differences between genotypes were highly significant for all the characters studied indicating thereby the presence of genetic variability among genotypes included in the present study. Pooled analysis also indicated significant variation among the environments and their influence on these characters. Highly significant mean squares due to environment (linear) indicated that environment differed considerably for different dates of sowing. However, the genotype x environment component was found to be significant only for days to flowering, plant height, 1000 seed weight, harvest index and oil content (Table 1). This indicated differential response of genotypes to varying environmental conditions. Whereas non-significance of mean square genotypes x environment for other characters showed linear response of genotypes to varying environments i.e., genotypes tended to adapt themselves with the change in the environment.

Further partitioning of genotype x environment interaction into linear and non-linear components revealed that mean square due to both linear and non-linear components were significant for plant height, 1000-seed weight, harvest index and oil content, when tested against pooled error. Whereas for seed yield, only linear component and for days to flowering and number of primary branches non-linear component was found to be significant. However, a major portion of genotype environment interaction was accounted for by the non-linear component in case of days to flowering, plant height, number of primary branches and 1000

Table 1. Analysis of variance for stability parameter for various characters in coriander

Source/ character	d.f.	Mean sum of square										
		Days to flowering	Days to maturity	Plant height (cm)	No. of primary branches plant^{-1}	No.of umbel plant^{-1}	No.of umbellets umbel^{-1}	No.of seeds umbel^{-1}	1000-seed weight (g)	Seed yield plant^{-1} (g)	Harvest index (%)	Oil content (%)
Genotype (G)	19	83.13**oo	102.13**oo	98.62**oo	0.48**oo	12.20**oo	0.47**oo	21.83**oo	9.34**oo	0.56**oo	37.45**oo	0.00695**oo
Environment (E)	2	301.48**	170.96**	85.20**	8.45**	18.57**	0.72**	44.22**	6.87**	3.22**	238.03**	0.00115**
GxE	38	8.63**	4.85	8.40**	0.15	1.25	0.11	2.81	1.83**	0.13	13.01**	0.00018**
E+(GxE)	40	21.37**	13.16**	12.24**	0.57**	2.11	0.14	4.88**	2.08**	0.29**	24.27**	0.00023**
E (Linear)	1	602.96**++	341.91**++	170.40**++	16.90**++	37.14**++	1.45**++	88.43**++	13.73**++	6.44**++	476.06**++	0.00231**++
GxE (Linear)	19	5.68	7.19++	5.58*	0.07	1.53	0.16++	3.11	1.02**	0.15	14.68**	0.00021
Pooled Deviation	20	7.20*	2.39	10.66**	0.22*	0.91	0.06	2.38**	2.51	0.11	10.78**	0.00014*
Pooled error	114	3.55	4.46	3.05	0.13	1.54	0.14	2.41	0.01	0.09	6.04	0.00007

*,+, o and **,++, oo significant at 5% and 1% respectively

o Tested against GxE, + Tested against pooled deviation, * Tested against pooled error

Table 2a. Estimates of stability parameters in coriander genotypes

Genotype	Days to flowering			Days to maturity			Plant height (cm)			No. of primary branches plant^{-1}			No.of umbel plant^{-1}			No.of umbellets umbel^{-1}		
	$\bar{X}$	bi	S2di	$\bar{X}$	bi	S2di	$\bar{X}$	bi	S2di	$\bar{X}$	bi	S2di	$\bar{X}$	bi	S2di	$\bar{X}$	bi	S2di
UD262	71.89	1.11	17.59*	102.44	0.73	-4.40	64.52	1.28*	-3.00	5.51	1.45	-0.09	20.11	1.81	-0.41	5.79	-1.27	0.12
UD-340	71.22	1.03	16.80*	103.56	0.35	-3.79	63.04	1.24	3.57	5.86	0.94	0.22	20.06	1.13	-1.33	5.18	0.83*	-0.14
UD-447	68.56	0.15	-3.26	104.78	1.23*	-4.35	64.87	0.82	-2.88	5.84	1.42*	-0.13	19.42	0.48	1.37	5.76	2.48	0.00
UD-685	71.78	00.61	-2.17	103.33	0.79*	-4.40	59.28	0.56	2.40	4.99	0.91	-0.06	23.31	1.79	-0.49	5.71	3.05	0.00
UD686	69.44	0.70	3.47	103.33	0.39*	-4.45	65.22	1.92*	-2.98	5.59	0.80	-0.09	17.91	0.33	-1.28	5.06	3.16	-0.09
UD-743	68.22	0.91	1.53	105.33	0.76	-1.73	56.83	1.27	-1.39	5.21	1.15	-0.12	18.94	1.10	1.24	5.29	-0.05	-0.08
UD-744	73.11	0.61*	-3.55	104.44	0.40	-1.30	58.82	1.61	14.77*	5.44	1.27	0.17	21.66	2.85	-0.65	4.90	-0.20	-0.03
CS-2	66.00	1.77*	-3.09	107.11	1.03	-4.31	63.42	1.12	1.88	5.81	0.91	0.12	20.47	1.54	-0.54	5.82	-0.38	-0.10
Rcr-20	71.89	0.77	-3.01	106.89	0.40	7.32	64.67	0.34	-2.38	6.01	1.42	0.30	20.93	1.40	-1.17	5.70	2.50	-0.10
Rcr-41	86.33	0.28	0.25	123.44	2.14	-1.55	71.28	2.35	0.04	6.48	1.09*	-0.13	23.06	1.69	-0.03	6.60	1.27	-0.05
Rcr-435	73.89	0.86	6.00	114.00	2.83	6.99	62.90	0.28	0.14	5.60	1.15	0.57*	19.81	-0.72	0.16	5.17	-0.24	-0.13
Rcr-436	61.78	1.33	46.57**	104.78	0.83	-4.25	63.08	-0.17	16.49*	5.86	0.87	1.42**	20.11	0.50	-0.03	5.21	0.11	-0.12
Rcr-446	69.89	1.39	-1.12	111.44	1.47	2.42	60.50	1.34	27.19**	5.52	0.26	0.35	22.28	1.59	-1.50	5.32	2.04	-0.12
Rcr-684	70.11	1.14	3.78	110.00	0.66	-1.01	60.91	-0.01	27.21**	5.59	1.12	-0.11	17.79	0.52	-1.18	5.26	-0.26	-0.13
Leafy type	70.78	0.86*	-3.44	109.33	1.30	-3.85	66.92	2.29	18.08**	5.89	0.88	-0.10	15.38	0.84	0.77	4.98	-0.22	-0.11
G.Cori-1	65.44	1.54	-2.51	108.56	0.96	-4.29	56.36	0.63	22.19**	5.00	0.93	-0.09	17.92	0.94*	-1.53	5.21	0.95	-0.06
G.Cori-2	68.89	0.94	-3.09	108.22	1.84*	-4.14	53.94	0.57	-2.97	5.92	0.82	-0.11	20.06	2.42	-1.47	5.22	-0.87	-0.11
Patan Mandi-1	62.00	1.71	4.37	98.78	0.65	-2.35	52.59	-0.59	13.39*	4.96	0.71	-0.12	17.11	0.01	-1.50	5.43	3.92	-0.12
Patan Mandi-2	64.67	0.93*	-3.47	98.56	0.55	-4.29	49.24	1.98	-0.38	5.12	0.97*	-0.13	19.16	-0.23	-0.92	5.11	1.63	-0.04
Jhalawar-1	65.22	1.38	1.20	98.00	0.68	-3.62	50.62	1.16	20.80**	5.27	0.95	-0.08	17.84	0.01	0.73	5.46	1.57	-0.12
Mean	69.56	1.00	3.64	106.32	1.00	-2.07	60.45	1.00	7.61	5.57	1.00	0.09	19.67	1.00	-0.63	5.41	1.00	-0.08
SE(b)		0.49			0.37			1.12				0.09				0.70		0.93

*, ** Significant at 5% and 1% level, respectively.

Table 2b. Estimates of stability parameters in coriander genotypes

Genotype	No. of seeds umbel^{-1}			100 seed weight (g)			Seed yield plant^{-1} (g)			Harvest index (%)			Oil content		
	$\bar{X}$	bi	S2di	$\bar{X}$	bi	S2di	$\bar{X}$	bi	S2di	$\bar{X}$	bi	S2di	$\bar{X}$	bi	S2di(x-5)
UD262	29.02	2.05*	2.36	12.79	1.22	3.60**	3.86	1.79	0.07	25.96	0.47	8.29	0.35	0.14	0.16
UD-340	27.53	1.73	2.23	14.46	1.12	1.98**	3.33	1.63	0.23	23.79	0.15	3.85	0.34	1.09	-0.7
UD447	27.77	0.69	0.08	10.41	0.68	0.56**	3.49	0.88	0.07	26.27	2.13	25.60*	0.39	0.86	-0.6
UD-685	27.09	1.83	0.09	11.50	1.80	7.18**	2.86	0.34	0.00	22.19	0.95	0.85	0.32	0.59	0.9
UD-686	26.22	1.81	0.07	11.12	0.19	0.35**	3.09	1.19	0.06	20.79	0.01	3.36	0.31	1.60	0.6
UD-743	28.83	0.94	1.66	11.39	1.70	4.23**	3.49	0.01	0.07	29.57	1.79	17.27	0.30	0.23	-0.7
UD-744	29.19	1.46	1.83	14.19	0.58	0.20**	3.84	1.64*	0.09	21.78	0.03	3.46	0.39	1.07	-0.5
CS-2	34.23	0.41	9.88*	10.38	0.41	0.87**	3.77	1.57	0.04	23.04	0.27	13.15	0.40	0.01	-0.6
Rcr-20	30.81	1.13	15.05**	11.20	1.41	0.06*	4.10	0.83	0.09	27.34	0.93	3.91	0.31	2.23	-0.3
Rcr-41	34.43	2.33	1.69	8.57	0.01	0.01	3.64	1.22	0.03	20.41	0.01	5.39	0.21	0.85	-0.4
Rcr-435	32.88	1.28	1.93	9.77	0.16	0.01	3.32	0.67	0.09	27.83	1.33	5.10	0.39	0.86	-0.6
Rcr-436	31.23	1.46	2.24	11.23	1.89	7.73**	3.37	0.78	0.08	24.04	1.56	5.64	0.32	0.73	0.7**
Rcr-446	34.01	0.18	0.75	9.40	0.32	0.07*	3.86	1.55	0.05	28.68	1.05*	5.98	0.39	0.51	0.11
Rcr-684	32.73	0.01	2.32	12.82	2.19	12.49**	2.80	0.77	0.04	21.17	1.24	9.80	0.31	2.70	0.7
Leafy type	30.66	0.84	1.07	9.36	0.03	0.23**	3.07	0.46	0.17	19.60	1.38	5.74	0.38	2.36	0.5
G.Cori-1	33.10	0.21	1.38	14.29	0.37	0.76**	4.16	1.39	0.08	31.05	1.65	0.35	0.40	0.21	-0.7
G.Cori-2	33.74	0.12	0.80	13.48	4.18	0.35**	3.52	1.53	0.08	25.08	1.37	3.34	0.35	0.20	-0.5
Patan Mandi-1	33.17	0.52*	2.40	12.29	2.02	2.35**	3.63	0.75	0.13	31.19	2.54	4.11	0.37	4.48	0.6**
Patan Mandi-2	28.89	1.46*	2.40	13.68	1.05	3.47**	3.14	0.98	0.09	26.26	1.41	24.13*	0.36	3.01	0.9
Jhalawar-1	28.06	1.48	1.76	12.07	2.22	3.43**	2.58	1.80	0.21	23.20	0.29	34.13*	0.29	0.21	-0.7
Mean	30.68	1.00	0.02	11.72	1.00	2.49	3.45	1.00	0.02	24.96	1.00	4.74	0.35	1.00	0.27
SE(b)		0.73			1.91			8.57			0.67			1.09	

*, ** Significant at 5% and 1% level, respectively.

seed weight. Low magnitude of linear and high magnitudes of non-linear component for these traits indicated that prediction of genotypes would be difficult for these traits. Ali *et al.* (1999) observed non-significant linear component for seed yield plant^{-1}, number of umbellets umbel^{-1}, number of seeds, number of primary branches plant^{-1} and days to maturity. However, for these unpredictable characters, prediction can still be made if one consider stability parameters of individual genotypes.

The seed yield of coriander fluctuates considerably with the change in environmental conditions. Hence, a variety possessing reasonable stability for seed yield is desirable. Different measures of stability have been used by various workers. Finlay & Wilkinson (1963) considered linear regression as a measure of stability, whereas Eberhart & Russell (1966) emphasized that both linear (bi) and non-linear (S^2di) components of genotype-environment interaction be considered while judging the phenotypic stability of a genotype. From the subsequent studies on this aspect it is suggested (Breese 1969; Paroda & Hayes 1971) that linear regression (bi) could simply be regarded as a measure of response of particular genotype, whereas, deviation from regression (S^2di) should be considered as a measure of stability. Accordingly, the mean ($\overline{X}$) and deviation from regression (S^2di) of each genotype were considered for stability and linear regression (bi) was used for testing the varietal response. Genotypes with lowest or non-significant mean square deviation being the most stable and *vice-versa*. The three parameters $\overline{X}$, bi and S^2di together gave an idea of adaptability of genotypes across the different dates of sowings. The mean ($\overline{X}$), regression coefficient (bi) and deviation from regression (S^2di) for seed yield are presented in Table 2a & b.

Estimation of stability parameters for seed yield and other traits revealed that 1000 seed weight seems to be the most unstable trait as eighteen of twenty genotypes were unstable. This was followed by the trait plant height with eight unstable genotypes. It was also evident from the ANOVA for stability, showing high magnitude of pooled deviation in comparison to linear component of genotype x environment interaction. On the other hand, seed yield plant^{-1}, number of umbels plant^{-1}, number of umbellets umbel^{-1} and days to maturity were the most stable traits as none of the genotypes was found to be unstable for these traits.

Stability parameters of individual genotypes for various traits revealed that none of the genotypes was desirable and stable simultaneously for all the traits studied. Based on the mean seed yield plant^{-1} ($\overline{X}$) and least S^2di (deviation from regression), G.Cori-1 ($\overline{X}$ = 4.16g) with highest seed yield and below average response (bi > 1.0) proved to be stable and suitable for high yielding environment. This genotype also exhibited stability for all other traits except plant height and 1000 seed weight. Interstingly this genotype was bold seeded with high number of seeds, a rare combination. However, the other promising genotype RCr-20 with bi < 1.0 could be considered stable but least responsive to changes in environmental conditions. Thus, exploitation of RCr-20 for poor environmental conditions would be desirable. Besides these two varieties, the other stable and promising genotypes were UD-262, RCr-446 and UD-744, CS-2, RCr-41 and G.Cori-2 with below average response for most of the characters, they could be exploited/suitable for better management facilities. For further breeding programme, exploitation of these genotypes would be useful particularly in moisture stress conditions or better management conditions accordingly.

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