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Genetic variability, heritability and genetic advance studies in coriander (*Coriandrum sativum* L.) under normal and staggered moisture regimes

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Abstract
The present investigation was undertaken to assess the genetic parameters in coriander. The thirty genotypes of coriander were evaluated under normal (E1) and limited moisture (staggered moisture regimes) (E2) conditions during *rabi* 2016-2017 in Randomized Block Design with three replications. The high significant differences (mean squares) due to genotypes were observed for all the characters studied in both the environment E1 and E2 as well as on pooled basis indicated sufficient genetic variability was present among the genotypes. The mean squares due to genotype x environment were also found significant for all the traits under study indicated role of environment on character expression. The moderate estimates of GCV and PCV were observed for branches per plant, umbels per plant, umbellets per umbel, seeds per umbel and seed yield per plant in both the environments. The estimates of broad sense heritability were observed to be high for all the characters in both the environments except for the traits plant height, branches per plant and umbellets per umbel in E2 environments. The genetic advance as percentage of mean was obtained high for branches per plant, umbels per plant, umbellets per umbel and seeds per umbel in E1 environments and for seeds per umbel in E2 environments. Thus, based on the present investigation it is suggested that in breeding programmes major emphasis should be given to branches per plant, umbels per plant and seeds per umbel as these characters had moderate GCV, PCV and high heritability coupled with high genetic advance as per cent of mean.

Keywords: Variability, heritability, genetic advance, coriander normal and staggered moisture conditions

1. Introduction

India is well known as "land of spices" across the world since long back and seed spices have emerged as one of the most important group of spice crops of our country. Coriander (*Coriandrum sativum* L.) also called 'Dhania' (Hindi), is an important seed spice crop grown around the world for its fruits as well as for tender green leaves. Taxonomically, coriander is a member of family Apiaceae and believed to be a native of Western Europe and Asia (Gal *et al.* 2010) [3]. It is highly cross pollinated diploid species having chromosome number 2n=22. It is an annual herbaceous plant extensively grown in India. The plant is an annual herb, with erect stem, 1 to 3 feet high, slender and branched. The inflorescence is a compound umbel with white or purple flowers. The leaves and seeds of coriander have a pleasant odour and used for preparation of chutneys and pickles. It is used as a spice in culinary (Diederichsen, 1996) [2], medicine (Kubo *et al.* 2004) [7] and in perfumery, food, beverage, and pharmaceuticals industries (Jansen, 1981) [5]. The seeds are also considered to be carminative, diuretic, stomatic tonic, antibilious, refrigerant and aphrodisiac (Murty and Sridhar, 2001) [9]. The aromatic odour and taste of coriander fruits is due to presence of essential oil called "coriandrol" (Pruthi, 1976) [12]. The starting point of any breeding programme is the collection of large germplasm and genetic variability present in the germplasm forms the basis for crop improvement. The adequacy of the genotypes is determined by the amount of genetic variability present in the germplasm and information on nature and magnitude of variability for different important characters to judge the potentiality of the germplasm collection. The parameters of genotypic and phenotypic coefficients of variation (GCV and PCV) are useful in detecting the amount of variability present in the available genotypes. The estimates of heritability and genetic advance help in determining the influences of environment in expression of the characters and extent to which improvement is possible after selection.

Keeping in view the present study was undertaken to assess the variability parameters as magnitude of variability, heritability, genetic advance for seed yield and its component characters in coriander.

2. Materials and Methods

In the present investigation, thirty genotypes of coriander taken from germplasm collection of AICRP on Spices located at Department of Plant Breeding and Genetics, S.K.N. College of Agriculture, Jobner. These genotypes were evaluated in Randomized Block Design with 3 replications in each environment E1 (normal environment) and E2 (limited moisture environment) during *rabi* 2016-17 at Agronomy Farm of S.K.N. College of Agriculture, Jobner. The normal environment (normal regime) (E1) was created by providing required irrigations from sowing to maturity of the crop whereas, the limited moisture environment (staggered moisture regimes) (E2) was created by providing half of the irrigations as given in normal environment in staggered manner. In each replication, each genotype was sown in a single row plot of 3 m length. The row to row and plant to plant distance was maintained at 30 cm and 10 cm, respectively. All the standard package of practices were followed to raise a good and healthy crop. The observations were recorded on five randomly selected plants tagged before flowering from each plot to record the data on plant height (cm), branches per plant (cm), umbels per plant, umbellets per umbel, seeds per umbel and seed yield per plant (g). However, data on days to 50% flowering, days to maturity and test weight (g) were recorded on whole plot basis. The data obtained in this study were subjected to appropriate statistical analysis to obtain information all genetic parameters.

2.1 Statistical Analysis

The analysis of variance was carried out separately for each environment as E1 and E2 as well as on pooled basis using the mathematical model of Panse and Sukhatme (1985) [11] and Singh and Choudhary (1985) [16]. The genotypic (σ^2_g) and phenotypic (σ^2_p) coefficient of variations were calculated by the standard statistical procedure suggested by Burton (1952) [1] for each trait in each of the environment. The estimates of broad sense heritability (h^2_{bs}) were estimated as per the method suggested by Johnson *et al.* (1955) [6]. The expected genetic advance (GA) for each character was calculated according to the method suggested by Johnson *et al.* (1955) [6].

3. Result and Discussion

The analysis of variance (Table 1) revealed that mean squares due to genotypes were found highly significant ($P< 0.01$) for all the characters in both the environments indicated inherent differences among the genotypes for all the characters under the study which can be exploited for improvement of seed yield in coriander. The analysis of variance on pooled basis (Table 2) revealed highly significant ($P< 0.01$) mean squares due to genotypes for all the characters under the study suggesting the material had adequate variability and response to selection may be accepted in the breeding programmes aiming for improvement in seed yield or any of its supporting characters. The mean squares due to interaction effects (G x E) were also found significant for all the characters under the study indicated influence of environmental factors on the character expression. These results are in agreement with the findings of Singh and Prasad (2006) [18], Singh and Singh (2013) [17] and Singh *et al.* (2018) [15] in coriander. The estimates of mean, range, genotypic variance (σ^2g), phenotypic variance (σ^2p), genotypic coefficient variance (GCV), phenotypic coefficient variance (PCV), heritability (H^2bs) and genetic advance (GA) as per cent of mean for nine characters in coriander under normal (E1) and limited moisture condition (E2) are presented in Table 4. The overall mean of genotypes were found higher in normal environment (E1) than limited moisture for all the characters except for days to 50% flowering and days to maturity indicated moisture stress induces earliness in plants (E2 environment). Similarly the range was also wider in normal environment (E1) in comparison to limited moisture (E2) environment for all of the characters except days to 50% flowering. The categorization of different parameters for assessing genetic variability are presented in Table 3. The genotypic and phenotypic variances were higher in normal environment (E1) than limited moisture environment (E2) for all the characters except for days to 50% flowering. This indicated the influence of moisture stress on character expression by the genotypes under the study. In both the environments (E1 and E2) high estimates of coefficients of variation were observed for characters *viz.*, days to 50% flowering, branches per plant, umbels per plant, umbellets per umbel, seeds per umbel, test weight and seed yield per plant thus, selection may be more effective for these characters because response to selection is directly proportional to the variability present in the experimental material. The low estimates of coefficient of variations were observed for days to maturity and plant height in both the conditions, which indicated that selection might not be effective for these characters. The parameters of genotypic and phenotypic coefficients of variations are useful in detecting the amount of variability present in the available genotypes. The magnitudes of genotypic and phenotypic variances were higher in normal condition (E1) than limited moisture condition (E2) for all the characters except for days to 50% flowering. The phenotypic coefficients of variations (PCV) were found higher than the corresponding genotypic coefficient of variation (GCV) for all the characters, which indicated effect of environments on the character expression. However, the differences were narrow which implied their relative resistance to environmental variations. It also described that genetic factors were predominantly responsible for expression of those attributes and selection could be made effectively on the basis of phenotype performance. The estimates of PCV and GCV were found moderate (10-20) for branches per plant, umbels per plant, umbellets per umbels and seeds per umbels in E1 environment, whereas for umbellets per umbels, seeds per umbel and seed yield per plant and in E2 environment. This indicated that simple selection for these characters might be advantageous as compared to other component characters under study. The estimates of GCV and PCV were found comparatively low for days to 50% flowering, days to maturity and plant height indicated little scope for exploitation of genetic variation for these characters. The maximum GCV and PCV were obtained for umbellets per umbel followed by branches per plant, seeds per umbel and umbels per plant under normal condition indicated better potential for further gain and improvement for these characters. The heritability helps in determining the influences of environment on expression of the characters and extent to which improvement is possible after selection. It is heritable portion of the phenotypic variance and a good index of the transmission of characters from parents to their offspring's. The estimates of heritability help the breeder in selection of elite genotypes from diverse genetic populations. The breeder appreciates the proportion of variation that is due to the genotype (broad sense heritability) or additive (narrow sense heritability) effects i.e. the heritable portion of variation of the first case and the portion of genotypic variation that is fixable in pure lines in the later case. If heritability of a character is high (>60%), selection for such a characters should be fairly easy. This is because there would be close correspondence between genotypic and phenotypic variation due to a relatively smaller contribution of environment to the phenotype, but for a character with a low heritability (<30%), selection may be considerably difficult or virtually impractical due to masking effect of environment on the genotypic effect. The magnitude of heritability was found higher in normal condition (E1) than limited moisture condition (E2) for most of the characters under study. The estimates of heritability changed very little between the environments for characters days to 50% flowering, seeds per umbel, test weight and seed yield per plant, whereas the change was considerable for days to maturity, plant height, branches per plant, umbels per plant and umbellets per umbel. The estimates of broad sense heritability (h^2 bs) were found higher for days to 50 per cent flowering, days to maturity, umbels per plant, seeds per umbels, test weight and seed yield per plant under both the conditions (E1 and E2) indicated these traits was least influenced by the environmental effects and selection for improvement of such traits might be useful. Similarly, the estimates of broad sense heritability (h^2 bs) were found moderate for the traits plant height, branches per plant and umbellets per umbel in limited moisture condition (E2) indicated these traits were highly influenced by the environments. The Heritability estimates alone do not provide information on the amount of genetic progress that would result from the selection of the best genotype. Therefore, genetic advance as percentage of mean was calculated in order to determine the relative merits of different characters that can be further utilized in the selection programme. Genetic advance (GA) is also of considerable important because it indicates the magnitude of the expected genetic gain from one cycle of selection. The estimates of genetic advance were found higher for most of the traits in normal condition (E1) than limited moisture condition (E2). The estimates of genetic advance were found higher (>20) for the traits branches per plant, umbels per plant, umbellets per umbels and seeds per umbels in normal condition (E1) and only for seeds per umbels in limited moisture condition (E2) indicated these traits were governed by additive gene action and selection will be rewarding for improvement of such traits. Similarly, the moderate (10-20) estimates of genetic advance were found for the traits days to 50 per cent flowering, branches per plant (only in E2), Umbels per plant (only in E2), test weight and seed yield per plant. The low estimates of genetic advance were found for days to maturity and plant height in both the conditions (E1 and E2) and for umbellets per umbel in limited moisture condition (E2) indicated that these traits were governed by non-additive gene action and heterosis breeding may be useful for improvement of such traits. Johnson *et al.* (1955) [6] has pointed out that heritability estimates along with genetic advance are more useful than heritability estimates alone in predicting the response to selection and thus both parameters should be considered for making an effective selection. Therefore, high heritability (> 60%) coupled with high genetic advance as percentage of mean (> 20%) was more reliable to determine the relative merits of different characters that can be further utilized in the selection programme. In present investigation high heritability coupled with high genetic advance as percentage of mean were observed for branches per plant, umbel umbels per plant, umbellets per umbel and seeds per umbel in E1 condition and for seeds per umbel in E2 condition indicated these characters may be under the control of additive gene action and selection for these characters may be effective. Similar findings were also reported by Jain *et al.* (2003) [4], Rajput and Singh (2003) [13], Meena *et al.* (2004) [8] and Nair *et al.* (2013) [10] who also reported high variability (GCV and PCV), heritability, genetic advance for the traits branches per plant, umbels per plant and seeds per umbel in coriander. Thus, based on the present investigation it is suggested that in breeding programmes major emphasis should be given to branches per plant, umbels per plant and seeds per umbel as these characters had high GCV, PCV, heritability, genetic advance, in coriander.

Table 1: The analysis of variance for nine characters in coriander under normal (E2) and limited moisture condition (E2) in coriander.

Source of variance	d.f.	Environments	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches per plant	Umbels per plant	Umbellets per umbel	Seeds per umbel	Test weight (g)	Seed yield per plant (g)
Replication	2	E1	4.9	0.41	16.71	0.8	0.91	0.18	1.38	0.35	0.03
		E2	1.48	0.21	17.08	0.13	1.81	0.02	1.86	0.11	0.02
Genotypes	29	E1	120.69**	94.41**	55.72**	2.79**	23.76**	1.7**	27.80**	5.26**	0.73**
		E2	144.48**	69.83**	28.62**	1.39**	15.53**	0.53**	17.72**	3.14**	0.50**
Error	58	E1	4.38	2.6	7.43	0.39	2.08	0.28	2.27	0.51	0.09
		E2	2.68	4.94	6.83	0.28	2.59	0.21	1.46	0.26	0.06

* and ** represent level of significance at 5% and 1%, respectively.

Table 2: The pooled analysis of variance for nine characters in coriander.

Source of variance	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches per plant	Umbels per plant	Umbellets per umbel	Seeds per umbel	Test weight (g)	Seed yield per plant (g)
Environments (E)	1	608.67**	2449.42**	2890.41**	49.61**	698.95**	25.22**	849.77**	68.06**	99.61**
Replications/E	4	3.188	0.313	16.893	0.468	1.36	0.103	1.62	0.228	0.028
Genotypes (G)	29	258.663**	155.639**	72.019**	3.199**	31.744**	1.798**	25.863**	7.385**	1.113**
G x E	29	6.511*	8.595**	12.316*	0.989**	7.548**	0.438*	19.657**	1.017**	0.122*
Error	116	3.534	3.765	7.129	0.338	2.334	0.244	1.865	0.386	0.075

* and ** represent level of significance at 5% and 1% respectively.

Table 3: Categorization of different estimates of genetic variability.

S.N.	Categories	Estimates of genetic variability			References
		GCV (%) and PCV (%)	Heritability (%) (H^2 bs)	Genetic advance (Percent of mean)	
1	Low	0-10	0-30	0-10	Sivasubramanian and Menon (1973) [19]
2	Medium	10-20	30-60	10-20	Robinson *et al.* (1949) [14]
3	High	>20	>60	>20	Johnson *et al.* (1955) [6]

Table 4: The estimates of mean, range, genotypic variance (σ^2g), phenotypic variance (σ^2p), genotypic coefficient variance (GCV), phenotypic coefficient variance (PCV), heritability (H^2 bs) and genetic advance (GA) as percent of mean for nine characters in coriander under normal (E1) and limited moisture condition (E2).

S. N.	Particulars		Days to 50% flowering	Days to maturity	Plant height (cm)	Branches per plant	Umbels per plant	Umbellets per umbel	Seeds per umbel	Test weight (g)	Seed yield per plant (g)
1	Mean	E1	75.43	132.26	77.23	7.51	23.31	5.21	24.84	12.77	5.01
		E2	71.76	124.88	69.22	6.46	19.37	4.46	20.5	11.54	3.52
2	Range	E1	54.67 - 84.33	119 - 144	65 - 84.33	5.00 - 10	15.93 - 27.30	4 - 6.80	20.17 - 32	9.13 - 15.16	4.42 - 6.15
		E2	52.33 - 82.33	115 - 133.67	62 - 75.13	4.47- 7.57	12.80 - 23.50	3.53 - 5.40	14.43 - 25.40	8.62 - 13.10	3.09 - 4.63
3	σ^2g	E1	38.77	30.6	16.1	0.80	7.23	0.47	8.51	1.58	0.21
		E2	47.27	21.63	7.26	0.37	4.31	0.11	5.42	0.96	0.15
4	σ^2p	E1	43.15	33.20	23.52	1.19	9.30	0.76	10.78	2.10	0.31
		E2	49.95	26.57	14.09	0.65	6.91	0.32	6.88	1.22	0.20
5	GCV (%)	E1	8.25	4.18	5.19	11.91	11.53	13.20	11.74	9.86	9.24
		E2	9.58	3.72	3.89	9.41	10.72	7.41	11.36	8.49	10.90
6	PCV (%)	E1	8.71	4.36	6.28	14.54	13.08	16.67	13.22	11.34	11.06
		E2	9.85	4.13	5.42	12.51	13.56	12.58	12.80	9.57	12.84
7	H^2 bs (%)	E1	89.84	92.18	68.43	67.14	77.69	62.65	78.93	75.56	69.78
		E2	94.63	81.42	51.53	56.54	62.45	34.73	78.80	78.75	72.14
8	GA (%)	E1	16.12	8.27	8.85	20.1	20.94	21.52	21.49	17.65	15.90
		E2	19.20	6.92	5.76	14.57	17.45	9.00	20.77	15.52	19.08

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