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Character association and path analysis in coriander [*Coriandrum sativum* (L.)]

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Abstract
The present study was conducted with the objective to know the extent of genetic variability, correlation and path coefficient analysis in a set of 216 accessions with eight checks of coriander in an Augmented Complete Block Design during *rabi* 2015-16. Analysis of variance showed significant differences among the accessions for all the characters studied except 1000-seed weight and days to maturity while, significant variability among checks were noted with respect to all the characters except umbellets per umbel and days to maturity. The high estimates of heritability and genetic advance were found for the characters seed yield per five plants and seeds per umbel. The highest percentage of PCV and GCV was observed for seed yield per five plants. Correlation studies revealed that seed yield per five plants exhibited highly significant and positive correlation with umbels per plant, 1000-seed weight and umbellets per umbel. Path analysis at both genotypic and phenotypic levels indicated that the magnitude of both direct and indirect effects were generally low. The direct effect of umbels per plant was found to be positive and highest. Based on the mean performance of the accessions, UD-431, UD-423 and UD-409 were found superior over check.

Keywords: Coriander, accessions, heritability, advance

Introduction
Coriander (*Coriandrum sativum* L.) also known as 'Dhania' is an important spice crop belonging to the family Apiaceae. It is a cross pollinated diploid species, possesses 2n = 22 chromosomes and plant is smooth, erect annual herb. It is one of the first spices to be consumed by human being as a common flavouring substance. Coriander is believed to have originated in Mediterranean region. A pleasant aromatic odour is present in the stem, leaves and fruits of the coriander, which is due to an essential oil containing α-linalool or coriandrol (Pruthi, 1976) [9].

Coriander is mainly a crop of tropics and sub-tropics. In India, it is mainly cultivated in the states of Rajasthan, Andhra Pradesh, Madhya Pradesh, Gujarat and Tamil Nadu covering an area of 447140 hectares with an annual production of 313640 tonnes and productivity 701 kg ha^{-1} (Anonymous, 2014-15) [1].

Breeding efforts have contributed substantially to improve yield potential, regional adaptation through resistance or tolerance to abiotic and biotic stresses, plant type and grain characteristics. Quantum of genetic variability and the extent to which heritable and non-heritable variations are related to the characters, determine the extent of genetic amelioration. Understanding of the association of different component characters towards yield forms the basic requirement for any selection programme. Path coefficient analysis is a standard tool for splitting the total correlation into direct and indirect effects of yield components on yield and this is more useful in identifying suitable selection indices.

The present investigation, therefore, was planned with these objectives which may provide the basic information on nature and magnitude of variability for important traits to be considered in crop improvement programme.

Materials and Methods
The material for the present investigation entitled "Character association and genetic divergence in coriander [*Coriandrum sativum* (L.)]" consisted of 216 accessions maintained under "All India Coordinated Research Project on Spices" at S. K. N. College of Agriculture, Jobner is situated 45 km away in the West of Jaipur at 26^0 05' North latitude and 75^0 28' East longitudes at an altitude of 427m above mean sea level. The accessions were evaluated during *Rabi* season (2015-16) at Research Farm in an augmented block design (Federer, 1956) [3].

The material was divided into 3 blocks. Each group of accessions was assigned to each block. Eight check varieties i.e. RCr-20, RCr-41, RCr-435, RCr-436, RCr-475, RCr-480, RCr-728 and Local check were also assigned randomly to each block. Each accession and check was sown in a double row plot. Each row was 3.0 m long and spaced 30 cm apart. Plant to plant distance was kept to 10 cm by thinning at 25th day after sowing. Observations were recorded on different morphological characters. Five plants were randomly selected from each plot to record the data on plant height, branches per plant, umbels per plant, umbellets per umbel, seeds per umbel, test weight and seed yield per five plants, while data on days to 50% flowering and days to maturity were recorded on whole line basis. The genotypic and phenotypic correlation coefficients were calculated as per methods given by Johanson *et al*. (1955) [5]. For the Path Coefficient Analysis, seed yield per plant was taken as the dependent variable while the rest characters were considered as the independent variables. The direct and indirect effects of the independent characters on seed yield per plant was estimated by simultaneous equation using the formula as applied by Deway and Lu (1959) [2].

Results and Discussion

The analysis of variance (Table-1) revealed that significant amount of variability was present in the accessions for all the yield and yield attributing characters through days to 50% flowering, plant height, branches per plant, umbels per plant, seeds per umbel and seed yield showed significant differences. The phenotypic variances were higher than genotypic variance indicating the role of environmental factors on the characters expression.

Heritability and genetic advance

The response to selection depends upon the relative magnitude of heritable variation present in relation to the phenotypic variation. The estimates of heritability were higher for seed yield except all the traits, which is in agreement with earlier report of Rajput and Singh (2003) [10]. Johanson *et al.* (1955) [5] had pointed out that the heritability estimates along with genetic advance were more useful than heritability estimates alone in predicting the response to selection. The expected genetic advance expressed as percentage of mean was observed to be high for seed yield followed by seeds per umbel, which are in accordance with the earlier report of Jain *et al*. (2003) [4] and Rajput and Singh (2003) [10].

Table 1: General mean, range, genotypic and phenotypic coefficients of variation, heritability (broad sense) and genetic advance as percentage of mean for different characters in Coriander

S. No.	Characters	Mean	Range	Genotypic coefficient of variation (GCV)	Phenotypic coefficient of variation (PCV)	Heritability in broad sense (%)	Genetic advance as percentage of mean
1	Days to 50% flowering	71.50	60.63-96.33	6.82	9.26	54.25	10.34
2	Plant height (cm)	109.44	67.33-157.33	11.89	15.35	59.96	18.96
3	Branches per plant	6.14	4.68-9.33	9.79	13.26	54.48	14.88
4	Umbels per plant	21.66	13.24-35.67	14.65	18.52	62.55	23.87
5	Umbellets per umbel	5.90	3.89-8.41	5.02	10.48	22.98	4.96
6	Seeds per umbel	31.41	16.15-58.53	17.62	20.06	77.14	31.88
7	1000- seed weight (g)	11.64	4.49-14.10	11.75	17.34	45.90	16.39
8	Days to maturity	136.80	131.67-145.79	0.40	1.36	8.48	0.24
9	Seed yield per five plants (g)	16.57	1.99-39.92	35.67	40.44	77.79	64.81

Table 2: Correlation coefficient between different characters in coriander at genotypic and phenotypic level

		Days to 50% flowering	Plant height (cm)	Branches per plant	Umbels per plant	Umbel lets per Umbel	Seeds per umbel	1000-seed weight (g)	Days to maturity	Seed yield per five plant (g)
Days to 50% flowering	r_g	1.0000	0.4925	0.2302	-0.0105	-0.2147	0.0768	-0.2749	0.6845	-0.1754
	r_p	1.0000	0.4920**	0.2300**	-0.0100	-0.2140**	0.0760	0.2740**	0.6810**	-0.1750**
Plant height (cm)	r_g		1.0000	0.4299	0.1628	-0.1657	0.1407	-0.2294	0.3916	0.0265
	r_p		1.0000	0.4290**	0.1630*	-0.1650*	0.1390*	0.2290**	0.3890**	-0.0260
Branches per plant	r_g			1.0000	0.4660	0.0666	0.1100	-0.0077	0.0753	0.0954
	r_p			1.0000	0.4660**	0.0660	0.1090	-0.0070	0.0740	0.0950
Umbels per plant	r_g				1.0000	0.3393	0.0972	0.1238	-0.2061	0.3301
	r_p				1.0000	0.3380**	0.0970	0.1230	-0.2050**	0.3300**
Umbellets per umbel	r_g					1.0000	0.1856	0.1943	-0.1188	0.1662
	r_p					1.0000	0.1890**	0.1940**	-0.1120	0.1660*
Seeds per umbel	r_g						1.0000	0.0197	0.0467	0.0090
	r_p						1.0000	0.0200	0.0480	0.0090
1000- seed weight (g)	r_g							1.0000	-0.3124	0.2694
	r_p							1.0000	-0.3100**	0.2690**
Days to maturity	r_g								1.0000	-0.1539
	r_p								1.0000	-0.1520*
Seed yield per five plant (g)	r_g									1.0000
	r_p									1.0000

* Significant at P=0.05 and ** Significant at P=0.01, rg = Correlation coefficient at genotypic level and rp = Correlation coefficient at phenotypic level

Table 3: Direct (diagonal) and indirect effects (non-diagonal) of different characters on seed yield in coriander at genotypic and phenotypic level

		Days to 50% flowering	Plant height (cm)	Branches per plant	Umbels per plant	Umbel lets per Umbel	Seeds per umbel	1000-seed weight (g)	Days to maturity	Correlation with seed yield per five plant (g)
Days to 50% flowering	r_g	-0.1948	0.0205	-0.0089	-0.0036	0.0016	-0.0014	-0.0598	0.0709	-0.1754**
	r_p	-0.1945	0.0205	-0.0089	-0.0034	0.0016	-0.0014	-0.0597	0.0704	-0.1750**
Plant height (cm)	r_g	-0.0959	0.0417	-0.0167	0.0550	0.0012	-0.0026	-0.0499	0.0406	-0.0265
	r_p	-0.0958	0.0415	-0.0167	0.0553	0.0013	-0.0025	-0.0498	0.0402	-0.0260
Branches per plant	r_g	-0.0448	0.0179	-0.0389	0.1576	-0.0005	-0.0020	-0.0017	0.0078	0.0954
	r_p	-0.0448	0.0179	-0.0388	0.1577	-0.0005	-0.0020	-0.0017	0.0077	0.0950
Umbels per plant	r_g	0.0021	0.0068	-0.0181	0.3381	-0.0025	-0.0018	0.0269	-0.0213	0.3301**
	r_p	0.0020	0.0068	-0.0181	0.3382	-0.0026	-0.0018	0.0269	-0.0212	0.3300**
Umbellets per umbel	r_g	0.0418	-0.0069	-0.0026	0.1147	-0.0074	-0.0034	0.0422	-0.0123	0.1662**
	r_p	0.0418	-0.0069	-0.0026	0.1144	-0.0075	-0.0034	0.0422	-0.0116	0.1660*
Seeds per umbel	r_g	-0.0150	0.0059	-0.0043	0.0329	-0.0014	-0.0182	0.0043	0.0048	0.0090
	r_p	-0.0148	0.0058	-0.0043	0.0329	-0.0014	-0.0181	0.0044	0.0050	0.0090
1000- seed weight (g)	r_g	0.0535	-0.0096	0.0003	0.0419	-0.0014	-0.0004	0.2174	-0.0324	0.2694**
	r_p	0.0535	-0.0095	0.0003	0.0419	-0.0015	-0.0004	0.2172	-0.0321	0.2690**
Days to maturity	r_g	-0.1333	0.0163	-0.0029	-0.0697	0.0009	0.0009	-0.0697	0.1036	-0.1539**
	r_p	-0.1325	0.0162	-0.0029	-0.0695	0.0009	-0.0009	-0.0674	0.1033	-0.1520*

Genotypic Residual effect = 0.904329 and * Significant at P = 0.05 and Phenotypic Residual effect = 0.904325, ** Significant at P = 0.01

Character association and path analysis

The study of correlation are needed to measure the association between yield and yield contributing characters which helps in identification of the important characters to be considered as a selection criterion in a breeding programme. The seed yield per plant had positive and significant association with umbels per plant (0.3300), 1000 seed weight (0.2690) and umbellets per umbel (0.1660), whereas branches per plant (0.0950) and seeds per umbel (0.0090) showed positive and non-significant association (Table-2). Similarly, days to 50% flowering (-0.1750) and days to maturity (-0.1520) had negative and significant association with seed yield per plant. Such associations were commonly reported in coriander by Sharma and Sharma (1989) [11], Kumar (2012) [7] and Meena *et al.* (2014) [8].

Association between two characters is evidence of pleiotropy rather than linkage hence under such complex situations, path coefficient analysis is a powerful tool for studying character association. Path coefficient analysis indicated that maximum direct contribution to seed yield was through umbels per plant followed by 1000 seed weight (Table-3). However, the attributes like umbels per plant had highest positive correlation with seed yield and had high positive direct effect on seed yield. These findings are in accordance with the report of Singh *et al.* (2006) [12].

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