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Bhuwanesh Didal
Mahatma Jyoti Rao Phoole University, Jaipur, Rajasthan, India

G Lal
ICAR-National Research Centre on Seed Spices, Tabiji, Ajmer, Rajasthan, India

PK Kaswan
Sri Karan Narendra Agriculture University, Jobner, Rajasthan, India

Gulab Choudhary
Sri Karan Narendra Agriculture University, Jobner, Rajasthan, India

Deepak Gupta
Sri Karan Narendra Agriculture University, Jobner, Rajasthan, India

Manju Netwal
Sri Karan Narendra Agriculture University, Jobner, Rajasthan, India

Corresponding Author:
Bhuwanesh Didal
Mahatma Jyoti Rao Phoole University, Jaipur, Rajasthan, India

Genetic variability, heritability, genetic advance and coefficient of variance analysis in coriander (*Coriandrum sativum* L.)

Bhuwanesh Didal, G Lal, PK Kaswan, Gulab Choudhary, Deepak Gupta and Manju Netwal

Abstract
The present investigation was conducted in the field of the Horticulture Research Farm, ICAR-National Research Center on Seed Spices, Tabiji, Ajmer (Raj.) during the crop season 2016-17. The experiment was conducted with 8 genotypes (ACr-1, Azad Dhania-1, RCr-435, RCr-436, RCr-446, RCr-684, Hisar Sugandh and Hisar Anand) in Randomized Block Design with four replications. Analysis of variance indicated that significant variation were found for plant height (30, 60, 90 days), days to 50% flowering, number of seeds per umbel, days to first flowering, number of umbels per plant, number of secondary branches, seed yield per hectare, seed yield per plant, test weight, days to harvesting, number of umbellets per umbel while, number of primary branches, days to germination and essential oil content were found non-significant. The highest estimates of GCV along with PCV were found for number of seeds per umbel, essential oil, seed yield per plant, number of umbellets per umbel while, moderate to high GCV & PCV were found for the characters *viz*., days to first and 50% flowering, number of primary and secondary branches and reaming characters *viz*., days to harvesting, days to germination and test weight were found low. The estimate of heritability was found very high for seed yield per hectare followed by number of seeds per umbel, days to 50% flowering, essential oil, test weight seed yield per plant and number of secondary branches for high while, low for days to germination. The genetic advance was recorded highest for number of seeds per umbel, essential oil, seed yield per plant and number of umbellets per umbel seed yield per hectare while, low in days to required harvesting, number of umbels per plant, test weight and days of germination.

Keywords: Coriander, genetic variability, heritability, genetic advance

Introduction
Coriander (*Coriandrum sativum* L.) is an annual herb and also known as Cilantro (English) and Dhania (Hindi). It is the only true species of the genus and it is a cross pollinated crop while, pollination occurred by honey bees. Rajasthan and Gujarat are known as "Seed Spices Bowl" contributes more than 80% of the total seed spices production of the country.

In India, the major growing states of coriander are Rajasthan, Madhya Pradesh, Andhra Pradesh, Gujarat, Uttar Pradesh and with scattered pockets in Tamil Nadu, Karnataka, Orissa and Haryana (Singh *et al*. 2013) [16]. Coriander was covering an area of 469.9 thousand hectare with a production of 600.4 thousand million tonnes with an average productivity of 1278 kg/ha (DASD, 2018-19) [6]. Rajasthan is major coriander producing state with its share of about 60% in the total area and production of the country (Malhotra and Vashishtha, 2008) [11]. The important coriander growing districts of Rajasthan are Kota, Jhalawar, Baran, Bundi and Sawai Madhopur. A study on variability available in the material is the prerequisite for initiating a varietal development programme. Hence, analyzing the nature and magnitude of the heritable genetic variation present in the material is necessary. The survey of genetic variability with the help of suitable genetic parameters like genotypic and phenotypic coefficients of variations, heritability estimates and genetic advance as percentage of mean are indispensable in breeding programmes aimed at improvement of seed yield. The heritability measures the contribution of genetic variability to the total variability i.e. phenotypic variability observed for any quantitative trait. The estimated heritability can be utilized for the estimation of genetic gain expected for the selection of top 5% individuals; such studied enable the breeders to have a maximum selection response of the variance exhibited by the population which is largely due to additive genetic effects.

Materials and Methods

Field experiment was conducted at Horticulture Research Farm, ICAR-National Research Center on Seed Spices, Tabiji, Ajmer (Raj.) during the Rabi season of 2016-17. Geographically Ajmer is situated at 74^0 35' 39" to 74^0 36' 01" E longitude and 26^0 22' 12" to 26^0 22' 31" N latitude at an altitude of 460.17 m above mean sea level in sub-mountainous region of Aravali hills. The region falls under IIIA Agro climatic zone of Rajasthan. The climate of this zone is typically semi-arid and sub-tropical characterized by mid-winter and moderate summers, high humidity during the month of July-September. The mean annual rainfall is 529 mm, mostly received from South-West monsoon during the last week of June to October. The experiment was laid out in a Randomized Block Design with four replications. The healthy seed of eight genotypes of coriander *viz*., ACr-1, Azad Dhania-1, RCr-435, RCr-436, RCr-446, RCr-684, Hisar Sugandh and Hisar Anand sown in field at row to row distance 30 cm and plant to plant distance of 10 cm in first week of November 2016. All recommended agronomic practices and plant protection measures were timely followed. The observation on matric traits such as, days to germination, plant height 30, 60 and 90 DAS, number of primary and secondary branches days to first and 50% flowering, days to harvesting, number of umbels per plant, number of umbellets per umbel, number of seeds per umbel, seed yield per plant (g), seed yield per hectare (q), test weight (g) and essential oil (%), was recorded at different stages of crop. The observation was recorded on 5 plants, selected at random. The phenotypic and genotypic coefficients of variation were worked out as per Burton (1952) [4]. Heritability in broad sense was estimated according to the formula given by Hanson *et al*. (1956) [8] by using Indostat Software.

Result

Analysis of variance showed that significant differences were observed in all the characters except number of primary branches per plant and essential oil, exhibited significant differences among the genotypes. (Table 1)

Table 1: Analysis of variance for morphological characters of coriander (mean sum of squares)

Source of variation	D. f.	Days to germination	Plant height (cm)			No. of primary branches per plant	No. of secondary branches per plant	Days to 1st flowering	Days to 50% flowering	Days to required harvesting	No. of umbels per plant	No. of umbellets per umbel	No. of seeds per umbel	Seed yield per plant (g)	Seed yield per hectare (q)	Test weight (g)	Essential oil (%)
			30 DAS	60 DAS	90 DAS												
Replication	3	0.33	0.02	4.79	61.37	0.065	0.20	1.86	1.12	0.458	0.534	0.05	0.51	0.27	0.014	0.27	0.000012
Varieties	7	0.93	5.72**	66.92**	285.39**	1.99	20.17**	88.98**	236.78**	5.91**	40.73**	3.15**	202.43**	9.34**	14.96**	7.12**	0.0070
Error	21	0.38	0.23	4.037	35.040	0.18	0.31	2.64	2.92	0.63	1.98	0.08	1.61	0.22	0.012	0.16	0.00012

The mean performance of the varieties (Table 2) revealed a wide range of variability for all the traits. The ranged highest for days to harvesting (126.25-130.25), plant height at 90 days (56.81-83.91), days take to 50% flowering (54.0-75.50), days to first flowering (45.0-58.50), plant height at 60 days (39.90-52.85), number of umbels per plant (35.25-44.38), number of seeds per umbel (11.28-32.75), number of secondary branches per plant (20.30-26.98), seed yield per hectare (12.17-17.02), test weight (12.49-16.72), days of germination (10.25-11.75), plant height at 30 days (5.55-9.23), seed yield per plant (5.08-9.20), number of primary branches per plant (5.65-7.68), while number of umbellets per umbel (3.63-6.25) and essential oil (0.123-.0234%) was found lowest. Ranges between lowest and highest values were found for different characters. It measures of variability of different characters related to yield. The wide variation can be used in future breeding programme. This finding is also in agreement with the findings of Arumugam and Muthurkrishnan (1979) [2] and Dyulgerov and Dyulgerova (2014) [7].

Table 2: Mean performances of coriander varieties for morphological characteristics

Varieties	Days to germination	Plant height (cm)			No. of primary branches per plant	No. of secondary branches per plant	Days to 1st flowering	Days to 50% flowering	Days to required harvesting	No. of umbels per plant	No. of umbellets per umbel	No. of seeds per umbel	Seed yield per plant (g)	Seed yield per hectare (q)	Test weight(g)	Essential oil (%)
		30 DAS	60 DAS	90 DAS												
Acr-1	10.75	7.63	52.85	83.91	7.38	25.53	58.50	75.50	130.25	41.55	5.93	32.75	9.20	16.32	12.49	0.215
Azad Dhania-1	10.25	9.23	52.20	79.86	7.68	26.98	55.75	70.50	128.75	44.38	6.25	19.00	8.87	17.02	16.59	0.234
RCr-435	11.25	6.88	50.28	68.21	6.48	23.28	50.50	56.25	127.00	38.08	4.78	13.58	5.73	12.18	15.73	0.123
RCr-436	11.00	5.75	39.90	56.81	7.03	20.96	46.75	55.50	127.00	35.63	4.63	12.33	7.70	12.17	16.72	0.170
RCr-446	11.50	5.55	49.91	68.84	5.65	20.30	45.00	54.00	126.25	35.25	3.63	11.28	5.08	12.22	15.85	0.201
RCr-684	11.50	6.38	48.18	71.90	6.33	23.10	47.75	59.50	127.75	37.08	4.35	13.35	7.48	12.93	15.66	0.127
Hisar Sugandh	11.00	6.10	50.67	74.35	6.08	22.13	49.25	60.00	128.00	36.03	4.08	12.58	6.20	12.74	15.99	0.202
Hisar Anand	11.75	7.15	51.12	78.31	7.25	24.28	47.00	58.00	128.25	39.13	4.90	13.93	8.50	13.72	16.17	0.149
C. D. 5% level	0.91	0.71	2.95	8.70	0.62	0.82	2.39	2.51	1.16	2.07	0.40	1.87	0.68	0.16	0.59	0.016
S.Em ±	0.31	0.24	1.00	2.96	0.21	0.28	0.81	0.86	0.40	0.70	0.14	0.63	0.23	0.05	0.20	0.006
C.V.	5.55	7.03	4.07	8.13	6.29	2.39	3.24	2.80	0.62	3.66	5.68	7.88	6.33	0.78	2.55	6.13

Coefficient of Variation

In the present findings phenotypic coefficient of variation were observed higher than the corresponding genotypic coefficient of variation for all the characters studied (Table 3). However, the differences were narrow which varieties consistence to environmental variation. It also described that genetic factors were predominantly responsible for expression of those at traits and selection could be made effectively on the basis of phenotypic performance. Tripathi *et al*., (2000) and Rajput and Singh (2003) [19, 15] were similar that of the present findings.

Table 3: Genetic parameters of yield and yield attributing characters in coriander

Characters		Grand Mean	Range		Coefficient of Variations		Heritability % (BS)	Genetic Advance	GA as % of Mean
			Min.	Max.	Phenotypic	Genotypic			
Days to germination		11.13	10.25	11.75	6.47	3.33	26.40	0.39	3.52
Plant height (cm)	30 DAS	6.83	5.55	9.23	18.54	17.16	85.60	2.23	32.70
	60 DAS	49.39	39.90	52.85	9.00	8.03	79.60	7.29	14.75
	90 DAS	72.77	56.81	83.91	13.58	10.87	64.10	13.05	17.93
No. of primary branches per plant		6.73	5.65	7.68	11.82	10.01	71.70	1.18	17.45
No. of secondary branches per plant		23.32	20.30	26.98	9.85	9.56	94.10	4.45	19.10
Days to first flowering		50.06	45.00	58.50	9.83	9.28	89.10	9.04	18.05
Days to 50% flowering		61.16	54.00	75.50	12.81	12.50	95.20	15.37	25.14
Days to required harvesting		127.94	126.25	130.25	1.09	0.90	67.90	1.95	1.53
Number of umbels per plant		38.39	35.25	44.38	8.90	8.11	83.10	5.84	15.22
Number of umbellets per umbel		4.82	3.63	6.25	19.08	18.21	91.10	1.73	35.82
Number of seeds per umbel		16.10	11.28	32.75	44.72	44.02	96.90	14.37	89.26
Seed yield per plant (g)		7.34	5.08	9.20	21.52	20.57	91.30	2.97	40.49
Seed yield per ha (q)		13.66	12.18	17.02	14.17	14.15	99.70	3.98	29.10
Test weight (g)		15.65	12.49	16.72	8.81	8.43	91.60	2.60	16.63
Essential oil %		0.178	0.123	0.234	24.13	23.34	93.50	0.083	46.50

Phenotypic coefficient of variations

The phenotypic coefficient of variation ranged from 1.09% for days to harvesting to 44.72% for number of seeds per umbel. The phenotypic coefficient of variations is high as compared to the genotypic coefficient of variation was observed in all the characters for almost characters indicated (Table 3).

The true genetic potential of high amount of genetic variability for these characters, thus selection may be more effective for these characters. The findings are in close harmony with the result of Maurya and Bineeta (2016) [12], Dyulgerov and Dyulgerova (2014) [7]. However, it was found to be low for characters like days to harvesting (1.09%), days to germination (6.47%), test weight (8.81%), number of umbels per plant (8.90%) and plant height at 60 DAS (9.00%). The findings are in close harmony with the result of Darvhankar *et al.* (2013) [5] and Kumar *et al.*, (2017) [10].

Genotypic coefficient of variation

It is revealed from the Table 3 that genotypic coefficient of variation varied from 0.90% for days to harvesting to 44.02% for number of seeds per umbel. High genotypic coefficient of variation was recorded from number of seeds per umbel (44.02%) followed by essential oil (23.34%), seed yield per plant (20.57%), number of umbellets per umbel (18.21%), plant height 30 DAS (17.16%), seed yield per hectare (14.15%). The high values of GCV suggested greater phenotypic and genotypic variability among the genotypes and responsiveness of the attributes for making further improvement by selection. The findings are in close harmony with the Verma *et al.* (2014) [20], Jain *et al.*, (2002) [9], Singh *et al.* (2008) [17], Meena *et al.* (2013) [13], Maurya and Bineeta (2016) [12], Dyulgerov and Dyulgerova (2014) [7]. However, it was recorded moderately for rest of the characters such as plant height at 90 DAS (10.87%), number of primary branches per plant (10.01%), number of secondary branches per plant (9.56%) and days to first flowering (9.28%), while it was found to be low for characters like days to 50% flowering (12.50%), days to harvest (0.90%), days to germination (3.33%), plant height at 60 DAS (8.03%), number of umbels per plant (8.10%) and test weight (8.43%). Arif *et al.* (2015) [1] was similar to that of the present findings.

The phenotypic coefficient of variation and genotypic coefficient of variation alone would not be sufficient to indicate the proportion of total heritable part of variation. The estimates of heritability were used to estimate genetic advance.

Heritability

High heritability in broad sense is helpful in identifying appropriate character for selection and enables the breeder to select superior varieties on the basis of phenotypic expression of quantitative characters. The estimated values of heritability in broad sense were classified as very high (above 90%), high (75-90%), medium (50-75%) and low (less than 50%). Result estimates and observed very high heritability for seed yield per hectare (99.70%) followed by number of seeds per umbel (96.90%), days to 50% flowering (95.20%), number of secondary branches per plant (94.10%), essential oil (93.50%), test weight (91.60%), seed yield per plant (91.30%) and number of umbellets per umbel (91.10%). High heritability recorded for days to first flowering (89.10%), plant height at 30 DAS (85.60%), number of umbels per plant (83.10%) and plant height at 60 DAS (79.60%). If heritability of a character is high (> 75%), selection for such a character should be fairly easy. This is because there would be correspondence between genotypic and phenotypic variation due to relatively smaller contribution of environment to the phenotype, but for a character with a low heritability, selection may be considerably difficult or virtually impractical due to masking effect of environment on the genotypic effect. Similar result was found in the findings of Singh *et al.* (2006) [18], Meena *et al.* (2013) [13], Arif *et al.* (2015) [1] and Kumar *et al.* (2017) [10]. Medium heritability recorded for number of primary branches per plant (71.70%) followed by days to harvesting (67.90%), plant height 90 DAS (64.10%). Similar findings also reported by Bhandari and Gupta, (1991). Low heritability recorded for days to germination (26.40%). This is indicative of the fact that characters are rather more influenced by the environment and may not respond much to selection.

Genetic advance

Estimates of genetic advance help to predict the extent of improvement that can be achieved for improving the different characters. The estimated values of genetic advance as percent of mean were classified as high (more than 40%), moderate (15-40%) and low (less than 15%). Genetic advance as percentage of mean ranged between days to required harvesting (1.53%) to number of seeds per umbel (89.26%).

The highest estimate of genetic advance as percentage of mean was recorded for number of seeds per umbel (89.26%), essential oil (46.50%) and seed yield per plant (40.49%). Similar result was found in the findings of Mengesha and Alemaw (2010) [14] and Jain *et al.,* (2002) [9]. However, number of umbellets per umbel (35.82%), plant height 30 DAS (32.70%) and seed yield per hectare (29.10%), days to 50% flowering (25.14%), number of secondary branches per plant (19.10%), days to first flowering (18.05%), plant height at 90 DAS (17.93%) and number of primary branches per plant (17.45%), test weight (16.63%), number of umbels per plant (15.22%), showed moderate value of genetic advance as percentage of mean in my studied. Similar result was found in the findings of Verma *et al.* (2014) [20] and Kumar *et al.* (2017) [10]. Whereas, low estimates were observed for days to harvesting (1.53%), days to germination (3.52%) and plant height at 60 DAS (14.75%). The results were closed proximate to that of Singh *et al.* (2006) [18].

High heritability and high genetic advance was observed for the characters seed yield per hectare, number of seeds per umbel, days to 50% flowering, number of secondary branches per plant, essential oil, test weight, seed yield per plant, number of umbellets per umbel and number of seeds per umbel, essential oil, seed yield per plant respectively indicated that these characters are governed by additive gene action. Hence, there are good chancers of improvement of these traits through direct selection in the present material. These types of similar results were reported by Arif *et al.* (2015) [1], Kumar *et al.* (2017) [10] and Verma *et al.* (2014) [20].

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