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Munish Kumar Verma
College of Horticulture & Forestry, Department of Vegetable Science, NDU A & T Kumarganj, Faizabad, UP, India.

VP Pandey
College of Horticulture & Forestry, Department of Vegetable Science, NDUAT Kumarganj, Faizabad UP, India.

Devraj Singh
College of Horticulture & Forestry, Department of Vegetable Science, NDUAT Kumarganj, Faizabad UP, India.

Sharvan Kumar
College of Horticulture & Forestry, Department of Vegetable Science, NDUAT Kumarganj, Faizabad, UP, India.

Prateek Kumar
College of Horticulture & Forestry, Department of Vegetable Science, NDUAT Kumarganj, Faizabad, UP, India.

Correspondence
Munish Kumar Verma
College of Horticulture & Forestry, Department of Vegetable Science, NDUAT Kumarganj, Faizabad, UP, India.

Studies on genetic variability in Germplasm of coriander (C*oriandrum sativum* L.)

Munish Kumar Verma, VP Pandey, Devraj Singh, Sharvan Kumar and Prateek Kumar

Abstract
The present investigation was conducted during November 2015- March 2016 at Main Experimental Station of Vegetable Science, Narendra Deva University of Agriculture &Technology, Kumarganj, and Fakirabad (U.P.). The field experiment was laid out in Augmented Block Design with 100 genotypes along with three checks in ten blocks accommodating ten genotypes and three checks in each block. The characters studied were Days to 50% flowering, plant height (cm), number of branches per plant,, number of fruiting nodes per plant, umbel diameter (cm), number of umbels per plant**,** number of fruits per umbel, number of umbellate per umbel, number of fruits per umbellate, 1000 seed weight (g)**,** seed yield per plant (g). Data were analyzed statistically for their mean, range, coefficient of variation and correlation, path. Analysis of variation due to the blocks were highly significant for all the characters except days to 50% flowering was significant and variance due to checks were significant for umbels per plant, fruits per umbel and fruits per umbellate while, highly significant for branches per plant and other characters are non-significant. Based on mean performance for yield and yield components, the NDCOR-78, NDCor-63, NDCOR-79, NDCor-91 and NDCor-81 were identified as most promising genotypes for seed yield per plant. The maximum genotypic coefficient of variation was observed for umbels per plant and phenotypic coefficient of variation was observed for seed yield per plant and lowest for days to 50% flowering, respectively.
The High yield per plant (35.89), branches per plant (33.37), test weight (32.81) and fruits per umbel (30.06). Highly significant and positive correlation coefficient of seed yield per plant was observed with test weight followed by fruits per umbel, umbellate per umbel, branches per plant and plant height. Path coefficient analysis carried out revealed test weight followed by fruiting nodes per plant, fruits per umbel, fruits per umbellate and umbels per plant had positive direct effect on seed yield per plant. The 103 genotypes of coriander were grouped in to eleven distinct clusters. Clustery had highest number of genotypes followed by cluster VIII, XI, X, III, VI, V, IX, II, I and VII. The Maximum intra-cluster distance was observed between cluster III (27.31) followed by cluster II (16.69). Maximum inter-cluster distance was observed between clusters III and cluster VIII (64.80) suggested that cluster is genetically very diverse to each other. Cluster I showed maximum mean value for yield per plant (12.13) followed by cluster X (10.93).

Keywords: Variability, correlation, cluster.

Introduction
Coriander is also known as the Chinese Parsely, Cilantro, Dizzycorn, and Japanese parsely. India is also known as "Home of Spices". Coriander is indispensable spice in the kitchen. It is among the first spices used by mankind, have been known as early as 5000 BC. Its description is also mentioned in Sanskrit writings dating from about 1500 BC. Moreover, references are also available with regard to Indian spices and their uses in Vedas (6000 B.C.) by Manu (4000 B.C.). India is the biggest producer, consumer and exporter of coriander in the world. According to Bureau of Indian Standards, 63 kinds of spices are grown in the country. Mainly, 52 spices are grown in India according to Spices Board, Calicut, and Kerala. Coriander is one of the most important seed spices crop grown throughout the world.
Coriander is botanically known as *Coriandrum sativum* L., 2n=2x=22, which belongs to the family Apiaceae (Umbelliferae). It is an annual, herbaceous plant which originated from the Mediterranean and Middle Eastern regions. It is mainly cultivated for its fruits as well as for the tender green leaves throughout the year. Coriander is now commercially grown in India, Morocco, U.S.S.R., Hungary, Poland, Rumania, Czechoslovakia, Guatemala, Mexico and the USA. In India, it is grown in Rajasthan, Madhya Pradesh, Gujarat, Assam, Andhra Pradesh, Orissa and Uttar Pradesh etc.
The states Rajasthan and Gujarat have emerged as "Seed Spices Bowl" is the major growing state and contributes about 80 per cent of coriander production in India. In the country,

it is grown on an area of about 663 thousand hectare with 609 thousand million tonnes production and 1.0 metric tonnes per hectares productivity (Anonymous 2016-17).

Coriander which is commonly known as Dhania. Coriander plant is a smooth, erect, annual herb, 30-90 cm high, with conspicuously enlarged nodes and hollow internodes. The stems are vertically ridged. The leaves are pinnately compound and often decompound. The lower leaves are broad with serenely-lobed margins. The upper leaves are finely cut with linear lobes. The petiole is often swollen even, hollow at the base and sheathing the stem. The leaf arrangement is alternate. The plant comes to the flowering stage in about 45-60 days after sowing. The flowers are small, white or pinkish in compound terminal umbels. There are 5 sepals, 5 petals, 5 stamens and two carpels which are free with an epigenous ovary. The fruit is a schizocarp, globular, yellow in color with brown ribs. The size seed is about 3.0 mm in diameter and ripe seed are aromatic. At dehiscence, the carpel called pericarp separate, each containing a single seed with a copious endosperm and a minute embryo.

Coriander is a great source of potassium, iron, vitamin A, K, C, folic acid, magnesium and calcium. Dry seed contains **0.1**-1.0 percent essential oil linalool which is used in food Industries. The volatile oil is used in cosmetic products and beverages. They are used for flavoring pastry, cookies-cakes, bakery products, meat, fish, soda, and syrups, candy preserves and liquor. Besides, coriander has profound medicinal values too. Indian spices and condiments have made significant export market in the world-trade. The major exporters of coriander are India, Morocco, Hungary, Poland, Romania and USA, while the importers are Malaysia, Singapore, UAE, South Africa, UK, Sri Lanka, Saudi Arabia and Germany (Raju, 1990).The genetic improvement of any crop depends upon its judicious exploitation through efficient following widely adopted breeding methods few high yielding varieties dominate in cultivation which often leads to genetic homogeneity. It is also well established that genetic homogeneity leads to genetic vulnerability to biotic and abiotic stresses. In any crop breeding programme, germplasm serves as the most valuable reservoir in providing variability for various traits. Genetic variability forms the basis for crop improvement. The success of any breeding programme depends upon the nature and the magnitude of genetic variability available in the breeding materials. Selection and hybridization approaches are easily followed in bringing about the quantitative improvement. Hence, it is essential to assess the nature and magnitude of variability, heritability and genetic advance for various characters in respect of germplasms available for maximizing the correlated response to selection. Besides, knowledge of inter-character association, direct and indirect effects on seed yield is also essential. Yield is the end product of various characters, which is directly or indirectly influences the growth of plant. The correlation co-efficient gives an idea about the various associations existing between the yield and yield components. It only reveals the direction and magnitude of association between any two characters but the path coefficient analysis helps in partitioning the correlation into direct and indirect effects of various yield components on yield.

Material and Methods

The present investigation was carried out at the Main Experiment Station, Department of Vegetable Science, Narendra Deva University of Agriculture and Technology, Kumarganj, Faridabad (U.P.) India, during Rabi 2015-16.

The details of materials used and methods employed during the present investigation have been referred in the subsequent paragraphs. The experiments were conducted at Main Experiment Station, Department of Vegetable Science, Narendra Deva University of Agriculture and Technology, (Narendra Nagar) Kumarganj, Faizabad (U.P.) India in well leveled field having proper drainage. This farm is situated in the main campus of the university on left side of Faizabad-Raebareli road at a distance of 42 km away from main city of Faizabad district.

Experimental materials

103 lines (100 test genotypes+3 checks) of coriander germplasm maintained in All India, in the augmented block. Co-ordinated Research project on spices under Department of Vegetable Science NDUA&T, Kumarganj, Faizabad were taken for this investigation. These genotypes were collected from different places of India.

Agronomical practices

Field preparation

One deep ploughing with a soil turning plough followed by 2 to 3 light sloughing's should be made to bring the soil to a fine tilth. All weeds and stubbles were collected manually and they were kept a side from the field. Well rotten Farm Yard Manure was thoroughly incorporated into the soil @ 10 tonnes/ha at the time of field preparation.

Fertilizer application

The required amount of chemical fertilizers were calculated on the basis of plot size and applied through urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O). The total amount of phosphorus, potassium and half quantity of nitrogen were applied as basal dressing in lines.

The remaining nitrogen was applied in two split doses *i.e.*, first 45 days after germination and second before flowering of the plant.

Training and cultural operation

The training and gap filling operations were done 25 days after germination. All the cultural operation were done as and when necessary for good stand of the crop.

To make the field free from weeds four weeding followed by hoeing were done with manually operated implements known as Khurpi and Kudal at 25 to 30 days after germination.

Harvesting of crop

The plant were ready for harvesting in the march, the maturity of the crop was assessed when leaves turn brown color and drying appearance. Harvesting should be done at a stage when 50 per cent grains turn yellow to obtain good luster of the grains. The plants are harvest with the help of sickle.

Statistical analyses

The experimental data collected in respect of 11 characters on 103 coriander genotypes and three checks were compiled by taking the mean values of selected plants in each plot and subjected for following statistical analyses:

Analysis of variance for augmented design

The analysis of variance for different characters in "Augmented Design" was done according to Federer (1956). The mean yield of checks and blocks are computed as under

Checks	Blocks			Total	Mean
	1	2……	10		
Hisar Anand	$X_{1.1}$	$X_{1.2}$……..	$X_{1.10}$	C_1	$\overline{X}_1$
ND Cor-2	$X_{2.1}$	$X_{2.2}$……..	$X_{2.10}$	C_2	$\overline{X}_2$
Pant Haritma	$X_{3.1}$	$X_{3.2}$……..	$X_{3.10}$	C_3	$\overline{X}_3$
Total	B_1	B_2	B_{10}	G	M

Where,

X_{ij} = Yield of i^{th}check in j^{th}block.

$B_j = \sum_{i}^{j} X_{ij}$ = Sum of all checks in j^{th} block.

$C_i = \sum_{j}^{i} X_{ij}$ = Sum of all yield of i^{th} check, over block.

$G = \sum B_j = \sum C_i$ = Grand total of all checks.

$\overline{X}i = C_i/b$ = mean of the i^{th} check.

$M = \sum \overline{X}i = G/b$ = Sum of all check means

b = number of blocks

c = number of check varieties.

Analysis of variance (ANOVA)

Source of variation	D f	S S	M S S
Blocks	b-1	SSB	MSB
Checks	c-1	SSC	MSC
Error	(b-1) (c-1)	SSE	MSE
Total	(bc-1)	SST	-

Where,

$$SST = \sum_{i}\sum_{j} X_{ij}^{2} - G^2/bc$$

$$SSB = \left(\frac{1}{c}\right)\sum_{j} B_j^{2} - G^2/bc$$

$$SSC = \left(\frac{1}{b}\right)\sum_{j} C_i^{2} - G^2/bc$$

MSS = SST- (SSB+SSC)

MSE = SSE/ (b-1) (c-1)

Then compute block effect r_j for each block where $r_j = \left(\frac{1}{c}\right)(B_j - M)$

After this, a table of adjusted yield for all the genotypes is prepared.

Where,

Y_{ij} = Yield of the i^{th} genotype in j^{th} block

$X_i = Y_{ij}-r_j$ =yield of the i^{th} variety adjusted for block difference.

Results and Discussion

Analysis ofvariation due to the blocks were highly significant for all the characters except days to 50% flowering was significant and variance due to checks were significant for umbels per plant, fruits per umbel and fruits per umbellate while, highly significant for branches per plant and other characters are non-significant. Based on mean performance for yield and yield components, the NDCOR-78, NDCor-63, NDCOR-79, NDCor-91 and NDCor-81 were identified as most promising genotypes for seed yield per plant. The maximum genotypic coefficient of variation was observed for umbels per plant and phenotypic coefficient of variation was observed for seed yield per plant and lowest for days to 50% flowering, respectively.

The High yield per plant (35.89), branches per plant (33.37), test weight (32.81) and fruits per umbel (30.06). Highly significant and positive correlation coefficient of seed yield per plant was observed with test weight followed by fruits per umbel, umbellate per umbel, branches per plant and plant height.

Analysis of variance

The result of analysis of variance for Augmented Design was carried out for 11 characters and the results obtained are presented in table 4.1.

The variation due to the blocks were highly significant for all the characters except days to 50% flowering was significant and variance due to checks were significant for umbels per plant, fruits per umbel and fruits per umbellate while, highly significant for branches per plant and other characters are non-significant.

Table 1: Estimates of range, general mean, genotypic and phenotypic coefficient of variation, heritability, genetic advance and genetic advance in percent of mean for 11 characters in coriander.

Parameters / Characters	Range		General mean	Genotypic coefficients of variation	Phenotypic coefficients of variation	Heritability (%)	Genetic advance	Genetic advance in percent of mean
	Min.	Max.						
	1	2	3	4	5	6	7	8
Days to 50% flowering	85.10	95.43	90.42	1.39	2.30	36.21	1.55	1.71
Plant height (cm)	107.11	154.37	135.09	6.05	6.64	83.07	15.34	11.36
Branches per plant	3.62	10.65	6.04	17.08	18.01	89.92	2.02	33.37
Fruiting nodes per plant	6.06	15.53	11.99	8.41	10.31	66.60	1.70	14.14
Umbel diameter (cm)	5.03	7.56	6.13	5.17	6.01	74.05	0.56	9.17
Umbels per plant	29.97	91.30	55.48	19.05	19.65	93.98	21.09	38.05
Fruits per umbel	33.34	77.34	45.73	16.51	18.67	78.15	13.74	30.06
Umbellates per umbel	5.11	7.87	6.53	6.97	8.70	64.10	0.75	11.49
Fruits per umbellate	4.77	10.11	6.90	14.10	15.55	82.13	1.81	26.31
Test weight (g)	6.17	17.54	9.60	16.79	17.70	90.01	3.16	32.81
Yield per plant (g)	5.85	17.28	8.99	18.56	19.77	88.12	3.23	35.89

Coefficients of variation

The range, general means, phenotypic coefficient of variation (PVC) and genotypic coefficient of variation (GCV), heritability in broad sense, genetic advance and genetic advance in per cent of mean for different character of coriander (*Coriandrum sativum* L.) germplasm are presented in table 4.3. The phenotype coefficient of variance was estimated in 100 genotypes for 11 characters.

Seed yield per plant (19.77) showed highest phenotypic coefficient of variation followed by umbels per plant (19.65), fruits per umbel (18.67), branches per plant (18.01), test weight (17.70) and lowest phenotypic coefficient of variation was observed for days to 50% flowering (2.30) followed by umbel diameter (6.01) While, highest genotypic coefficient of variation was observed for umbels per plant (19.05) followed by seed yield per plant (18.56), branches per plant (17.08), test weight (16.79), fruits per umbel (16.51), fruits per umbellate (14.10) and lowest genotypic coefficient of variation was observed for days to 50% flowering (1.39) followed by umbel diameter (5.17). Umbels per plant showed highest genotypic coefficient of variation, high heritability %, high genetic advance and high genetic advance in per cent of mean.

The analysis of variance for all the eleven traits showed existence of variability among the one hundred germplasm. The phenotypic variability may be due to genetic constitution of the material as well as environment influences. The genotypic and phenotypic coefficient of variations was computed to assess to existing variability in the genotypes (table 1). The high magnitude of coefficients of variation at genotypic level in case of umbels per plant and phenotypic level in case of seed yield per plant. The phenotypic coefficient of variation was higher than genotypic coefficient of variation, which indicates possibilities for obtaining very high selection response in respect of these traits. The high estimates of GCV and PCV for these traits were reported by several workers. The similar, results were reported by Bhandari*et al.* (1991), Bhandari*et al.* (1993), Srivastava*et al.* (2000), Rajput and Singh (2003) and Singh *et al.* (2005).

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