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Genetic distance in coriander (*Coriandrum sativum* L.) for essential oil yield and yield traits

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Abstract

Genetic association and distances were assessed in a collection of 15 Indian accessions of coriander, consisting of 8 land races and 7 cultivars, on the basis of seven economic plant traits including essential oil content and oil yield. The study revealed that genetic distance in the material was substantial with the D^2 values ranging from 37.4 (between the genotypes C-2 and DH-5) to 1309 (between the genotypes C-1 and RCr-20). The genotypes clubbed into 8 clusters. The genetic diversity was found to be independent of the geographical diversity of the genotypes. Considered together, the results of genetic association and D^2 analysis revealed that the variation in seed yield was the most prominent force accounting for both variations in oil yield and genetic distance in the material. The study suggested that improvement in this crop would be possible by exercising selection for oil yield, seed yield and their associated traits viz. oil content and umbellets per umbel. The results of D^2 values and cluster means permitted rational selection of S-33 and C-1, RCr-41 and PD-1, potent genotypes with complementary characters in morphological fitnesses for yield and its associated traits, for effective cross hybridization programme.

Key words: *Coriandrum sativum*, genetic diversity, hybridization.

Introduction

Coriander (*Coriandrum sativum* L.), a crop of Mediterranean origin and of immense importance for its seed spice, essential oil and culinary properties, is cultivated in India in about 400,000 hectares with a total production of 173,200 tonnes of seeds (Vedamuthu *et al.* 1994). The essential oil extracted from coriander seeds has high demand in food and perfumery industries. Although several reports are now available on genetic improvement in relevance to its seed productivity, there are very few reports on attempts to improve its essential oil yield (Dimri *et al.* 1976). A logical way to start any breeding and selection programme is to quantify the variation present in the germplasm. Precise information on the nature and degree of genetic distance would help the plant breeder in choosing the right type of parents for purposeful hybridization or heterosis breeding programme (Arunachalam 1981). Nevertheless, it is also emphasized that the outcome of the analysis of genetic distance would be of much practical meaning for breeding work if those are assessed for their consistence with the outcomes (rationales) of the correlation studies (Sachan & Sharma 1971; Patra 1985). An attempt was therefore made to study the genetic distance as well as correlation in this crop.

Materials and methods

The experimental material comprised of 15 acce-ssions (8 land races and 7 released cultivars) namely, C-1 (Rudrapur local), C-2 (Jyolikote local), C-3 (Banthara local), C-4 (Haldwani local), C-5 (Ramnagar local), C-6 (Pantnagar local), C-7 (Guna local, M.P.), C-8 (Udaipur local, Rajasthan), Pant-1 (variety developed by GB Pant Univ. of Agri. & Tech., Pantnagar), S-33 (introduction from Bulgaria by CIMAP), RCr-20 and RCr-41 (varieties from Rajasthan), PD-1 and Kalmi (varieties from Punjab) and DH-5 (variety from Haryana). The experiment was laid out in a randomized block design with four replications during 1994-95 and 1995-96 at Field Station of CIMAP, Pantnagar, India. The treatments in each replication consisted of five rows (5 m in length and 60 cm apart). Seeds were sown in the first week of November and after 5 weeks seedlings were thinned to keep 35 seedlings per row. Fertilizers, NPK were applied @ 100 : 60 : 40 kg ha^{-1}. Observations were recorded at the time of harvest in April on 10 randomly chosen plants from the middle rows of each plot.

Statistical analyses were performed on the basis of mean values of each plot pooled over two years. The mean data were subjected to multivariate analysis using Mahalanobis's generalized distance D^2. The 7 x 7 dispersion matrix was used for simultaneous testing of significance of differences in the cluster mean using Wilk's criterion and the varieties were grouped into clusters according to Tocher's method (Rao 1952). The criteria used for clustering was that any two varieties belonging to the same cluster, on an average, show a smaller intra-cluster distance than the inter-cluster distances. The canonical analysis was made for confirming the results of D^2 analysis of the n(n-1)/2 pairs of populations.

Results and discussion

All the seven characters studied exhibited significant genetic variability "V" statistics. It was observed that the differences between the means in respect of pooled effect of all the seven characters between different populations were significant. The mean performances of fifteen genotypes for seven economic traits (Table 1) indicated that the genotype C-1 was the best for seed and oil yield (1.5 t and 5.1 kg ha^{-1}), followed by the genotypes RCr-41 (1.3 t and 4.2 kg ha^{-1}), C-8 (1.0 t and 3.3 kg ha^{-1}) and C-3 (1.1 t and 3.1 kg ha^{-1}), respectively.

All the characters except plant height and number of umbels branch^{-1} exhibited significant positive correlations with oil content (Table 2). On the contrary three characters namely seed yield, oil content and number of umbellets umbel^{-1} showed significant positive correlation with oil yield. The results of correlation study revealed that among the various characters seed yield was the most desirable variate in view of its significant association with all plant traits except for number of umbels branch^{-1}.

Based on the D^2 values, 15 genotypes could be grouped into 8 clusters (Table 3 and Fig. 1). The maximum number of genotypes (4) was accommodated in cluster I followed by the cluster II with 3 genotypes, cluster III and IV with 2 genotypes each and clusters V, VI, VII and VIII each with a single genotype. Thus the single genotypes in the four clusters were more diverse than the genotypes in the other clusters. The pattern of distribution of genotypes from different ecological habitats into different clusters was at random. Different clusters were superior in respect of the mean values of the seven characters studied (Table 4). Among the eight clusters, cluster II comprising the genotypes C-1, RCr-41 and PD-1, showed moderate performances for the five characters and excelled the rest seven clusters for two major economic traits namely, seed and seed oil yield. It was interesting to note that the cluster VI having the single genotype (S-33) despite having high oil content (0.44%) and number of umbellets umbel^{-1}, showed low oil and seed yield (0.66 t ha^{-1}). The clusters V, VII and VIII, each having single genotype, Pant–1, C-4 and C-8, respectively,

Table 1. Expression of seed and oil yield related characteristics among 15 genotypes of coriander

Genotype	Plant height (cm)	No. of branches	No. of umbels branch^{-1}	No. of umbellets umbel^{-1}	Seed yield (t ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
C-1	103.50	16.55	6.85	6.68	1.50	0.34	5.05
C-2	87.25	8.18	5.10	6.90	0.54	0.16	0.84
C-3	77.00	10.25	6.93	6.60	1.10	0.30	3.11
C-4	79.75	10.00	7.75	6.83	0.11	0.11	0.12
C-5	97.25	12.25	6.15	8.10	0.91	0.28	2.48
C-6	82.75	7.35	7.60	5.68	0.90	0.24	2.12
C-7	101.75	6.65	5.25	4.93	0.15	0.14	0.21
C-8	84.00	23.08	6.50	6.68	1.00	0.33	3.27
Pant-1	124.50	7.83	5.85	4.10	0.71	0.16	1.16
S-33	66.00	13.08	6.35	8.18	0.66	0.41	2.73
RCr-41	117.25	12.18	5.93	7.33	1.33	0.31	4.18
PD-1	123.25	9.35	6.00	6.83	1.25	0.20	2.48
Kalmi	126.50	11.00	7.25	7.15	0.93	0.15	1.36
DH-5	90.50	8.95	6.03	6.68	0.30	0.16	0.48
RCr-20	105.00	7.10	5.83	4.83	0.08	0.10	0.07
CD at 5%	5.61	1.11	0.61	0.72	0.20	0.05	0.50
CV %	5.57	7.81	7.61	12.62	15.56	53.76	17.27

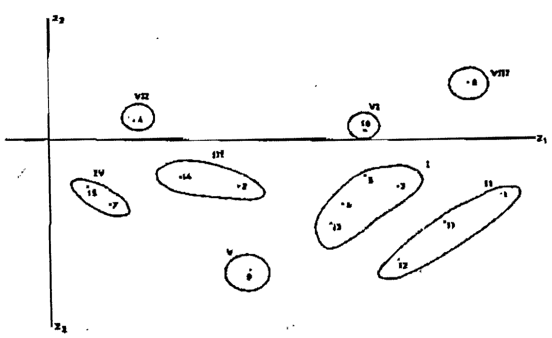

Fig. 1. Distribution of genotypes in Z_1 and Z_2 graph

were the best performers for the characters namely, plant height, number of umbels branch^{-1} and number of branches, respectively. The remaining three clusters, I, III and IV comprising 4, 2 and 2 genotypes, respectively showed poor performance for all the traits studied. The analysis for estimating the contribution of various characters towards the expression of genetic distances (Table 4) indicated that yield of oil and seed contributed maximum (47.4% and 30.6%, respectively) to the total genetic distance in this germplasm collection.

The D^2 values between pairs of populations for seven traits taken together, ranged from 37.4 between genotypes 2 and 14 to 1309 between genotypes 1 and 15 indicating thereby the presence of substantial diversity and little domestication in the material (Table 5). The intra-cluster distances ranged from 18.7 to 108.8 for cluster III and II, respectively and did not transgress the limits of any of the inter-cluster distances. Relative importance of the characters elucidated by D^2 analysis was further confirmed by canonical analysis. The proportion of contribution of two roots l_1 and l_2 to the variances of uncorrelated (transformed) variables were 82.30% and 17.70%, respectively. The values of two canonical vectors are given in Table 6. From the absolute size of the coefficient of canonical vectors, it was ascertained that seed yield and oil yield (especially the former) were the most potent characters in divergence, whereas the rest five characters namely, plant height, number of branches, number of umbels and umbellets and oil content had minor role in genetic differentiation.

The present study clearly showed that the populations of the fifteen genotypes have

Table 2. Genotypic (G) and phenotypic (P) correlations ($_\gamma$) of six plant traits with seed and oil yield and oil content in coriander

Plant trait	γ with seed yield		γ with oil content		γ with oil yield	
	G	P	G	P	G	P
Plant height	0.33*	0.32*	-0.29	-0.29	0.08	0.08
No. of branches	0.52**	0.50**	0.68**	0.65**	0.13	0.13
No. of umbels branch^{-1}	0.15	0.12	0.16	0.16	0.13	0.11
No. of umbellets umbel^{-1}	0.39**	0.35*	0.58**	0.52**	0.45**	0.42**
Oil yield	0.92**	0.90**	0.68**	0.66**	0.92**	0.90**
Oil content	0.68**	0.66**	0.87**	0.86**	0.87**	0.86**

* Significant at 1% level; ** Significant at 5% level.

Table 3. Distribution of 15 genotypes of coriander in eight clusters

Cluster	Number of genotypes	Genotypes
I	4	C-3 (Banthara-UP; Tropical), C-5 (Ramnagar-Uttranchal; Sub-tropical), C-6 (Pantnagar- Uttranchal; Sub-tropical) and Kalmi (Punjab; Tropical)
II	3	C-1 (Rudrapur- Uttranchal; Sub-tropical), RCr-41 (Rajsthan-Tropical arid), and PD-1 (Punjab-Tropical)
III	2	C-2 (Jyolikote-Uttranchal; Temperate) and DH-5 (Haryana- Tropical) IV
2		C-7 (Guna-M.P., Tropical) and RCr20 (Rajsthan-Tropical arid)
V	1	Pant-1 (Pantnagar- Uttranchal; Sub-tropical)
VI	1	S-33 (Bangalore-Karnataka; Sub-tropical)
VII	1	C-4 (Haldwani- Uttranchal; Sub-tropical)
VIII	1	C-8 (Udaipur- Rajsthan-Tropical arid)

Table 4. Cluster mean and percent contribution to divergence of seven characters in coriander

Character	Cluster means								Percent contribution
	I	II	III	IV	V	VI	VII	VIII	
Plant height (cm)	95.38	117.67	88.38	102.88	123.50	66.00	78.75	84.00	3.53
No. of branches	10.21	12.36	8.07	6.38	6.83	13.08	10.00	23.08	6.22
No. of umbels branch^{-1}	6.48	5.93	5.57	5.54	4.85	6.35	6.75	6.50	2.80
No. of umbellets umbel^{-1}	6.88	6.95	6.79	4.88	4.10	8.18	6.83	6.68	3.11
Seed yield (t ha^{-1})	0.96	1.36	0.42	0.12	0.71	0.66	0.11	1.01	30.62
Oil yield (kg ha^{-1})	2.27	3.90	0.66	0.14	1.16	2.73	0.12	3.27	47.42
Oil content (%)	0.24	0.28	0.16	0.12	0.16	0.41	0.11	0.33	6.30

Table 5. Mean intra and inter-cluster distance (D^2 values) in coriander

Cluster	I	II	III	IV	V	VI	VII	VIII
I	108.57	181.33	236.12	609.15	231.49	508.06	161.10	355.50
II		108.86	534.18	989.94	389.98	914.52	343.43	333.32
III			18.69	148.23	141.20	275.84	117.89	693.73
IV				19.12	258.25	710.89	114.39	1211.46
V					0	410.05	401.69	989.08
VI						0	531.04	316.72
VII							0	872.78
VIII								0

Table 6. Values of two canonical vectors (Z_1 and Z_2)

Character	Z_1	Z_2
Plant height	0.04	-1.00
No. of branches	0.34	0.70
No. of umbels branch^{-1}	0.08	0.57
No. of umbellets umbel^{-1}	0.86	0.25
Seed yield	0.99	0.82
Oil content	0.10	0.41
Oil yield	0.62	-0.29

significant genetic variability for all the seven traits studied, which can be utilized in individual plant selection, cross hybridization and population improvement programmes of coriander as done in other cross pollinated crops (Robinson 1966). It is clear that among the six characters studied (excluding the oil yield, the dependent variate) three namely, seed yield, oil content and number of umbelletes umbel^{-1} had significant association with oil yield. Hence, it is likely that these three characters are the best selection parameters for the prognosis of high oil yield in coriander genotypes. Dimri *et al.* (1976) reported that self pollination for even consecutive five generations did not result in marked deterioration in morpho-physiological vigour of this cross pollinated crop. Thus, it seems plausible that resorting to individual plant selection on the basis of the three major parameters (seed yield, oil content and umbellets umbel^{-1}) would be a wise proposition in ensuring genetic improvement in coriander. The results of D^2 analysis have demonstrated that among the seven characters studied, two namely, seed and oil yield are the greatest contributors to genetic diversity in the present collections of coriander as they accounted for 78% of total diversity. Dominance of these two characters, especially seed yield over the others in divergence could be confirmed by canonical analysis. It clearly indicated that seed and oil yields are the two basic attributes of plant architecture, which require greater attention for genetic improvement in coriander. The present study did not suggest that there is direct relationship or parallelism between the ecological distribution in the coriander genotypes and their genetic diversity. This is in agreement with other studies (Sachan & Sharma 1971; Murty & Arunachalam 1966).

Thus, the results of correlations and D^2 analysis revealed that the variation in seed yield is the most prominent force accounting for both variations in oil yield (as revealed by its high correlations with oil yield) and genetic divergence in the material. The study raises the possibility that improvement in this crop can be ensured through hybridization of the promising genotypes chosen on the basis of oil yield as well as its associated traits especially seed yield. Finally, the genotypes of cluster II and cluster VI having shown the complementarity for the traits, seed and oil yield, oil content and umbellet number, it appears likely that hybridization between them may result in promising derivatives in coriander.

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