Chapter 4

Empirical Studies

4.1 Characterisation of coriander germplasm through different qualitative and quantitative characters.

Several qualitative characters namely, leaf colour, leaf lustre, basal lobing, leaf blade shape, stem colour and seed shape have been recorded in all the 12 coriander germplasm (Table5). Frequency distribution of these qualitative characters of these germplasm is presented in Table 4.

The predominant leaf colour was green (58.33%) followed by dark green (41.66%) whereas all germplasm showed medium basal lobing and trifoliate. In case of stem colour, 41.66% each purple and green with purple streaks are shown in coriander germplasm, however, the rest 16.66% showed green stem colour.

Table 4: Frequency distribution for different qualitative characters in the coriander germplasm

Characters	Specification	Number of germplasm	% of germplasm
Leaf colour	Dark green	5	41.66
	Green	7	58.33
Basal lobing	Weak	0	0
	Medium	12	100
	Strong	0	0

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Characters	Specification	Number of germplasm	% of germplasm
Leaf blade shape	Simple	0	0
	Trifoliate	12	100
Stem colour	Green	2	16.66
	Purple	5	41.66
	Green with Purple streaks	5	41.66
Seed colour	Brown	5	41.66
	Yellowish brown	1	8.33
	Light brown	6	50
Seed shape	Elongated	1	8.33
	Medium elongated	8	66.66
	flattened	3	25

50.00% of the germplasms showed light brown colour of seed and 41.66% showed brown and 8.33%yellowish brown. The pre-dominant seed shape was medium elongated (66.66%) followed by light brown (50.00%) and elongated (8.33%).

All the 12 germplasms of coriander under study in two year showed wide range of variations in the quantitative characters recorded namely days to flowering, days to maturity, plant height, number of basal leaves, length of longest basal leaves, primary branches, secondary branches, umbels per plant, umbellets per umbel, number of seeds per umbel, oleoresin content, essential oil content, test weight, seed yield per plant, seed yield per plot and projected seed yield per ha. Moreover, all the coriander germplasm under study showed highly significant variations among the different characters as revealed from Table. 6.

Days to flowering differs significantly in all the genotypes ranging from 44.83-77.17days.The germplasm NRCS A.Cr-1 showed the maximum days followed by five X, Pant Haritma and so on. The results are in line with Singh *et al.*, 2011. West Bengal collection 1 was found to take minimum days to flowering. In case of days to harvesting the germplasm Manipur collection 1 was the earliest to harvest (94.17 days) followed by Assam

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collection whereas NRCS A Cr1 took maximum days (130.33) to harvest. Pant Haritma was found tallest (114.98cm) whereas Tripura collection was the shortest (64.76cm). The results are in line with Phurailatpam *et al.* (2016). Number of basal leaves was found highest in Arka Isha (9.50) followed by Pant Haritma, West Bengal collection1 showed the least number of basal leaves. The results are in line with Arif *et al.* (2014). Length of longest basal leaves was found maximum Pant Haritma (19.90) followed by Suvashini(14.40), West Bengal Collection-3 and so on. While West Bengal collection-1 showed the minimum. The result are in line with Chaulagain *et al*. (2011). The highest number of primary branch was found in NRCS A. Cr1 (10.50) whereas Manipur collection2 was recorded the least (3.83).

Table 5: Qualitative characters recorded in different coriander germplasm

Cultivar	Leaf colour	Leaf luster	Basal leave lobing	Leaf blade shape	Stem colour	Seed colour	Seed shape
Arka Isha	Dark Green	Shiny	Medium	Trifoliate	Green with purple streaks	Brown	Medium elongated
Manipur collection-1	Green	Shiny	Medium	Trifoliate	purple	Brown	Elongated
Suvashini	Green	Shiny	Medium	Trifoliate	purple	Brown	Flattened
West Bengal collection-1	Green	Shiny	Medium	Trifoliate	green	Light brown	Medium elongated
West Bengal collection-2	Green	Shiny	Medium	Trifoliate	purple	Light brown	Flattened
Assam collection	Dark Green	Shiny	Medium	Trifoliate	green	Light brown	Medium elongated
Five X	Dark Green	Shiny	Medium	Trifoliate	Green with purple streaks	Brown	Flattened

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Manipur collection-2	Green	Shiny	Medium	Trifoliate	Green with purple streaks	Light brown	Medium elongated
NRCSS A.Cr-1	Dark Green	Shiny	Medium	Trifoliate	purple	Brown	Medium elongated
Tripura collection	Green	Shiny	Medium	Trifoliate	Green with purple streaks	Yellowish brown	Medium elongated
Pant Haritma	Dark Green	Shiny	Medium	Trifoliate	purple	Light brown	Medium elongated
West Bengal collection-3	Green	Shiny	medium	Trifoliate	Green with purple streaks	Light brown	Medium elongated

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Plate 2: Different Stages of Growth

Plate 3: Developmental sequence of compound umbels seed

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Table 6: Performance of coriander genotypes in two years

Genotypes	Days to flowering			Days to maturity			Plant height(cm)			No. basal leaves			Length of longest basal leaves			No.Primary branches		
	1st year	2nd year	Pool	1st year	2nd year	Pool	1st year	2nd year	Pool	1st year	2nd year	Pool	1st year	2nd year	Pool	1st year	2nd year	Pool
Arka Isha	67.67	70.67	69.17	105.67	106.67	106.17	115.33	114.52	114.93	9.33	9.67	9.50	12.90	13.23	13.07	5.67	5.33	5.50
Manipur collection-1	50.00	51.33	50.67	93.67	94.67	94.17	74.67	69.89	72.28	3.67	3.33	3.50	12.73	12.83	12.78	5.33	5.67	5.50
Suvashini	59.33	58.33	58.83	102.33	103.67	103.00	106.02	106.41	106.21	5.67	6.67	6.17	14.30	14.50	14.40	6.67	6.33	6.50
West Bengal collection-1	43.33	46.33	44.83	99.00	100.67	99.83	76.83	75.85	76.34	3.33	3.00	3.17	9.30	9.27	9.28	4.33	4.67	4.50
West Bengal collection-2	53.00	57.67	55.33	119.00	118.67	118.83	108.11	102.91	105.51	7.67	7.33	7.50	11.97	12.30	12.13	7.33	7.00	7.17
Assam collection	42.33	47.33	44.83	96.67	98.67	97.67	78.33	76.26	77.30	4.33	3.67	4.00	12.50	12.10	12.30	4.00	4.33	4.17
Five X	73.33	71.00	72.17	117.33	118.00	117.67	108.67	102.86	105.76	6.67	6.33	6.50	9.60	9.73	9.67	7.33	7.67	7.50

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CD at 5%	SE(m)	West Bengal collection-3	Pant Haritma	Tripura collection	NRCSS A.Cr-1	Manipur collection-2
5.38	1.84	64.67	70.33	48.67	77.00	57.67
4.66	1.59	65.33	70.33	50.00	77.33	57.33
3.73	1.27	65.00	70.33	49.33	77.17	57.50
2.16	0.74	107.67	125.00	100.33	129.33	109.67
2.85	0.97	108.67	125.67	98.00	131.33	110.67
1.80	0.61	108.17	125.33	99.17	130.33	110.17
11.25	3.84	83.67	111.55	64.33	113.28	70.95
9.79	3.34	83.00	118.41	65.19	111.71	72.99
9.88	3.37	83.33	114.98	64.76	112.49	71.97
0.97	0.33	6.33	8.67	4.33	6.33	3.33
1.23	0.42	6.67	8.00	4.67	6.33	3.67
0.87	0.30	6.50	8.33	4.50	6.33	3.50
0.98	0.34	13.70	20.03	11.00	12.90	12.33
1.33	0.45	13.93	19.77	10.53	12.83	12.17
0.99	0.34	13.82	19.90	10.77	12.87	12.25
1.05	0.36	3.67	9.67	4.67	10.33	4.00
1.08	0.37	4.33	10.00	5.00	10.67	3.67
0.87	0.30	4.00	9.83	4.83	10.50	3.83

Genotypes	No. Secondary branches			No. umbels/plant			No. umbellets/umbel			No. seeds/umbel			Test Weight		
	1st year	2nd year	Pool	1st year	2nd year	Pool	1st year	2nd year	Pool	1st year	2nd year	Pool	1st year	2nd year	Pool

NRCSS A.Cr-1	Manipur collection-2	Five X	Assam collection	West Bengal collection-2	West Bengal collection-1	Suvashini	Manipur collection-1	Arka Isha
17.00	8.33	15.00	7.67	12.67	8.00	11.67	11.00	12.33
18.00	7.67	15.33	8.33	13.33	9.67	12.67	12.33	12.00
17.50	8.00	15.17	8.00	13.00	8.83	12.17	11.67	12.17
24.02	16.66	26.00	19.78	27.77	17.61	23.33	21.14	22.31
24.23	16.17	26.00	19.63	27.67	17.34	23.00	21.24	22.28
24.12	16.42	26.00	19.70	27.72	17.48	23.17	21.19	22.30
6.08	4.39	4.90	4.38	5.69	3.88	5.59	4.00	4.25
6.16	4.33	4.64	4.18	5.43	3.82	5.48	4.03	4.24
6.12	4.36	4.77	4.28	5.56	3.85	5.53	4.02	4.25
51.83	32.75	40.03	29.14	46.22	30.55	34.33	22.22	36.76
50.77	31.84	39.95	30.68	45.99	31.20	35.24	21.67	36.31
51.30	32.30	39.99	29.91	46.11	30.88	34.78	21.94	36.54
6.94	6.82	7.14	7.34	7.58	6.94	7.72	7.32	8.20
7.20	6.90	7.14	7.41	7.70	6.80	7.80	7.40	8.07
7.07	6.86	7.14	7.37	7.64	6.87	7.76	7.36	8.13

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Tripura collection	10.00	10.00	10.00	20.30	20.11	20.21	3.64	3.86	3.75	29.94	29.88	29.91	7.66	7.78	7.72
Pant Haritma	15.67	16.00	15.83	29.81	29.98	29.89	6.91	7.13	7.02	45.05	45.38	45.21	9.98	9.49	9.74
West Bengal collection-3	12.33	12.00	12.17	20.59	19.76	20.18	5.79	5.87	5.83	23.75	24.23	23.99	9.30	9.41	9.36
SE(m)	0.64	0.96	0.60	0.87	0.85	0.67	0.19	0.19	0.17	1.31	1.29	0.93	0.14	0.11	0.12
CD at 5%	1.89	2.82	1.76	2.57	2.49	1.96	0.56	0.56	0.50	3.84	3.78	2.72	0.42	0.32	0.35

Genotypes	**Test weight**			**Essential Oil(%)**			**Oleoresin (%)**			**Seed yield/plant(g)**			**Yield/plot(g)**			**Proj. yld/ha(q)**		
	1st year	**2nd year**	**Pool**	**1st year**	**2nd year**	**Pool**	**1st year**	**2nd year**	**Pool**	**1st year**	**2nd year**	**Pool**	**1st year**	**2nd year**	**Pool**	**1st year**	**2nd year**	**Pool**
Arka Isha	8.20	8.07	8.13	0.36	0.36	0.36	9.09	9.08	9.08	2.44	2.72	2.58	300.75	303.25	302.00	15.04	15.16	15.10
Manipur collection-1	7.32	7.40	7.36	0.26	0.25	0.26	5.20	5.19	5.20	1.21	1.27	1.24	150.70	159.37	155.04	7.54	7.97	7.75

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Pant Haritma	Tripura collection	NRCSS A.Cr-1	Manipur collection-2	Five X	Assam collection	West Bengal collection-2	West Bengal collection-1	Suvashini
9.98	7.66	6.94	6.82	7.14	7.34	7.58	6.94	7.72
9.49	7.78	7.20	6.90	7.14	7.41	7.70	6.80	7.80
9.74	7.72	7.07	6.86	7.14	7.37	7.64	6.87	7.76
0.35	0.23	0.23	0.25	0.29	0.28	0.31	0.27	0.28
0.34	0.25	0.24	0.25	0.28	0.27	0.30	0.27	0.27
0.35	0.24	0.24	0.25	0.29	0.28	0.31	0.27	0.27
6.00	6.08	12.85	5.80	7.42	3.24	6.37	4.21	10.69
6.02	6.10	12.88	5.82	7.42	3.27	6.39	4.20	10.68
6.01	6.09	12.87	5.81	7.42	3.26	6.38	4.20	10.69
6.03	3.50	5.52	1.12	3.78	1.63	5.73	3.29	2.66
6.31	3.38	5.67	1.18	3.66	1.87	5.76	3.25	2.51
6.17	3.44	5.60	1.15	3.72	1.75	5.75	3.27	2.59
442.04	218.92	382.67	181.13	327.08	172.81	336.33	278.09	292.44
448.71	235.26	386.00	190.79	320.82	180.14	343.16	266.99	282.36
445.37	227.09	384.33	185.96	323.95	176.48	339.75	272.54	287.40
22.10	10.95	19.13	9.06	16.35	8.64	16.82	13.90	14.62
22.44	11.76	19.30	9.54	16.04	9.01	17.16	13.35	14.12
22.27	11.35	19.22	9.30	16.20	8.82	16.99	13.63	14.37

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West Bengal collection-3	9.30	9.41	9.36	0.33	0.32	0.33	6.95	6.98	6.97	2.14	2.18	2.16	295.58	294.87	295.23	14.78	14.74	14.76
SE(m)	0.14	0.11	0.12	0.01	0.01	0.01	0.04	0.03	0.03	0.16	0.14	0.13	3.66	5.42	3.88	0.18	0.27	0.19
CD at 5%	0.42	0.32	0.35	0.03	0.03	0.03	0.11	0.09	0.10	0.48	0.42	0.37	10.73	15.90	11.39	0.54	0.79	0.57

In case of secondary branch NRCS A.Cr-1 was recorded the highest number (17.77) followed by Pant Haritma (15.83), Assam collection (8.00) showed the least. The result are in line with Giridhar *et al*. (2014). So far as the umbels per plant in concerned the germplasm Pant Haritma produced the maximum number of umbels per plant (29.89) followed by West Bengal collection-2, five X, etc. Whereas the germplasm Manipur collection 2 produced the minimum (16.42) number of umbels per plant. The range of umbellets per umbel in all the 12 germplasm under study varied from 7.02 in Pant Haritma to 3.75 in Tripura collection (Table-8). The results are in line with Malik and Tehlan (2013). In case of number of seeds per umbel the maximum value was observed in NRCS A.Cr-1 (51.30) followed by west Bengal collection-2, Pant Haritma and so on. On the other hand the minimum seeds/umbel was found with the germplasm Manipur collection-1 (21.94). Similar results have been obtained by Meena *et al*. (2010). Seed yield/plant in different coriander germplasms ranged from 6.17 g in Pant Haritma to 1.15 g in Manipur collection-2. The results are in line with Phurailatpam *et al* (2016). Test weight in different germplasms ranged from 9.74 in Pant Haritma to 6.86 in Manipur collection-2. The result are in line

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with Singh *et al.* (2011). Seed yield per plant was also influenced significantly. The essential oil yield was low in all variety. Among them Arka Isha yields the highest (0.36). In case of oleoresin content the maximum value was observed in NRCS A.Cr-1 (12.87) followed by Suvashini, Arka Isha and so on. On the other hand the minimum oleoresin was found with the germplasm Assam collection (3.26). Yield per plot was found highest in highest in Pant Haritma (445.37) followed by NRCS A.Cr-1 (384.33) whereas Manipur collection-1(155.04) recorded the least. The result are in agreement with the observations of Moniruzzaman *et al.*, 2013 and Meena *et al.*, 2010. So far as projected yield per ha is concerned highest yield was obtained in Pant Haritma (22.27) whereas Manipur collection-1 recorded the least of (7.75). Similar results have been obtained by Phurailatpam *et al.* (2016), Singh *et al.*(2012)and Giridhar *et al.*(2014).

4.2 Analysis of components of coriander fruit yield:

The development of suitable plant type is of great importance for all the crops through planned design programme. Attempts have therefore been made by several scientists to analyse different morphological characters to provide meaningful information about the significance of characters in relation to seed yield in coriander. An ideal plant ideotype would only be defined if the different components of coriander seeds are analysed and their relative importance can be assessed. In the present study, genetic diversity of coriander genotypes

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Table 7: Analysis of variance for eleven different characters in 12 genotypes of coriander

Source of variation (d.f.)	Mean Sum of Square (MS)										
	Days to flowering	Days to maturity	Plant height(cm)	No. basal leaves	No. Primary branches	No. Secondary branches	Umbels/plant	Umbellets/umbel	No. seeds/umbel	Test weight	Seed yield/plant
Replication (2)											
1st year	0.861	10.028	183.688	0.361	0.083	2.694	2.237	0.232	5.434	0.033	0.030
2nd year	5.083	0.111	75.710	0.528	0.528	2.861	1.061	0.042	6.641	0.022	0.011
Treatment (11)											
1st year	412.899	397.785	1,119.132	12.694	14.917	27.543	46.951	3.182	249.001	2.872	8.985
2nd year	329.280	405.263	1,144.176	13.232	15.111	28.960	51.091	3.394	236.142	2.301	9.203
Error (22)											
1st year	10.104	1.634	44.167	0.331	0.386	1.240	2.295	0.109	5.143	0.061	0.080
2nd year	7.568	2.838	33.416	0.528	0.407	2.770	2.166	0.111	4.986	0.036	0.062

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CV (%)											
1st year	5.39	1.17	7.17	9.91	12.57	9.43	6.75	6.65	6.44	3.18	8.69
2nd year	4.57	1.54	6.31	12.57	10.25	13.56	6.60	6.75	6.33	2.44	7.53

Table 8: Genetic variability parameters in different characters in first and second year of 12 coriander genotypes

		Days to flowering	Days to maturity	Plant height(cm)	No. basal leaves	No. Primary branches	No. Secondary branches	Umbels/plant	Umbellets/umbel	No. seeds/umbel	Test weight	Seed yield/plant
Mean	1st	58.94	108.81	92.65	[illegible]	6.08	11.81	22.44	4.96	35.21	7.75	3.25
	2nd	60.25	109.61	91.67	5.78	6.22	12.28	22.28	4.93	35.26	7.76	3.31
	P	59.60	109.21	92.16	5.79	6.15	12.04	22.36	4.95	35.24	7.75	3.28
Range	1st	42.33-77.0	93.67-129.33	64.33-115.33	3.33-9.33	3.67-10.33	7.67-17.0	16.66-29.81	3.64-6.91	22.22-51.83	6.82-9.98	1.12-6.03
	2nd	46.33-77.33	94.67-131.33	65.19-118.41	3.0-9.67	3.67-10.67	7.67-18	16.17-29.98	3.82-7.13	21.67-50.77	6.8-9.49	1.18-6.31

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Heritability (%) in b.s.		GCV (%)			PCV (%)			
		P			**P**			**p**
93.408	93.002	18.444	17.188	19.658	18.811	17.784	20.384	44.83-77.33
97.928	98.778	10.565	10.566	10.561	10.610	10.678	10.626	94.17-130.33
91.722	89.027	20.670	20.991	20.432	21.618	21.918	21.655	64.76-114.98
88.918	92.569	35.260	35.617	34.968	36.356	37.771	36.344	3.17-9.50
92.341	92.612	35.918	35.581	36.177	36.878	37.027	37.592	3.83-10.50
75.911	87.610	24.812	24.065	25.082	26.277	27.620	26.796	8.0-17.50
88.274	86.641	17.814	18.122	17.190	18.551	19.288	18.468	16.42-29.89
90.810	90.405	20.826	21.210	20.412	21.652	22.258	21.467	3.75-7.02
93.922	94.049	25.358	24.893	25.603	25.766	25.686	26.401	21.94-51.30
95.468	93.929	11.811	11.199	12.499	12.115	11.462	12.896	6.86-9.74
97.998	97.377	52.826	52.678	52.945	53.248	53.214	53.654	1.15-6.17

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	P	96.137	99.161	91.424	94.062	94.862	89.161	92.217	92.514	96.864	95.054	98.422
GA (%) of mean		39.053	21.623	39.714	69.306	71.719	48.362	32.962	39.980	51.149	24.954	107.627
		34.220	21.540	41.414	69.186	70.434	43.192	35.074	41.637	49.698	22.542	107.426
	P	37.254	21.672	40.714	70.447	72.065	48.263	35.240	41.265	51.413	23.722	107.959

1st = First year; 2nd= Second year; P= pooled over two years
PCV=Phenotypic Co-efficient of variation, GCV=Genotypic Co-efficient of variation

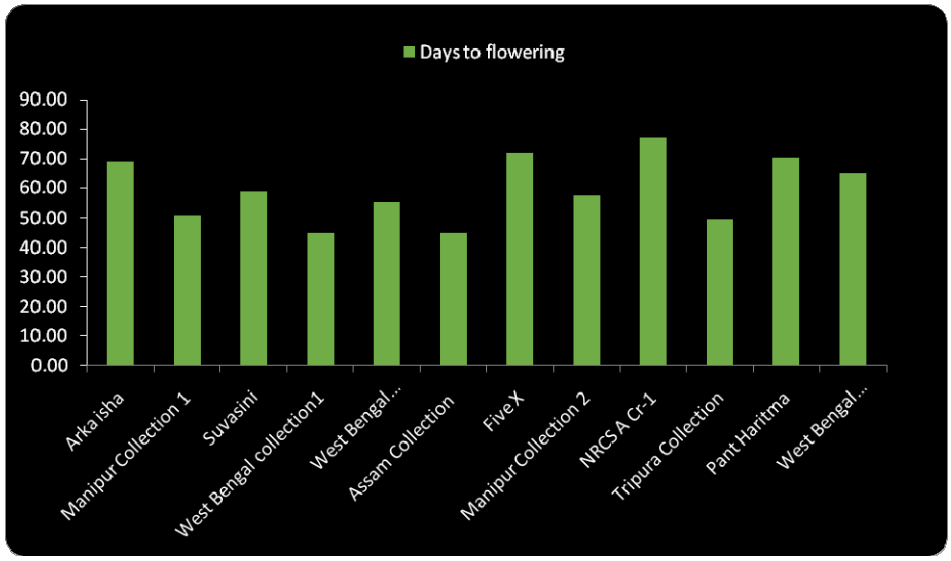

Fig. 8: Days to flowering

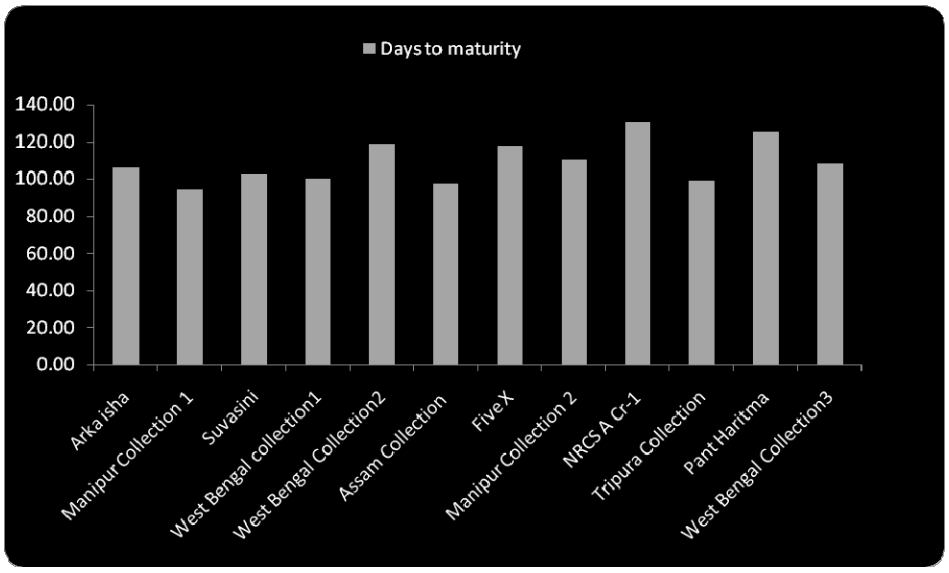

Fig. 9: Days to maturity

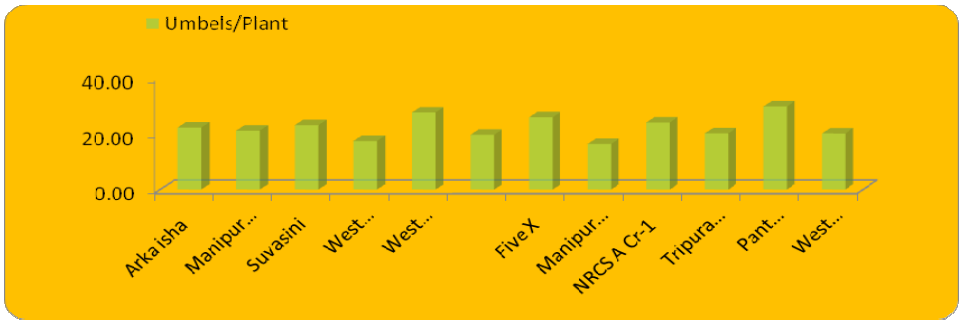

Fig. 10: Number of umbels per plant

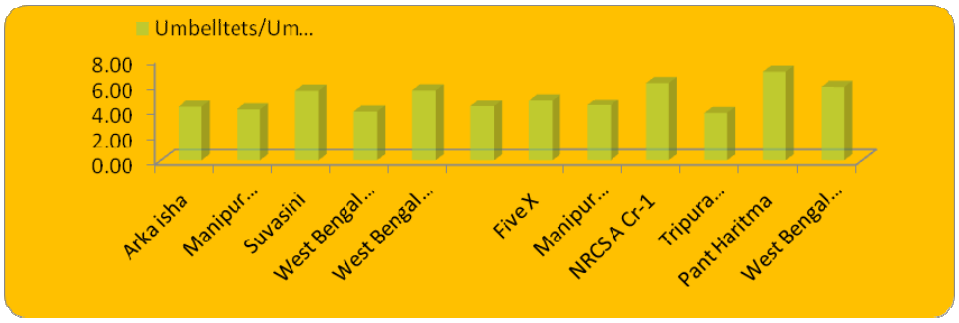

Fig. 11: Number of umbellets per umbel

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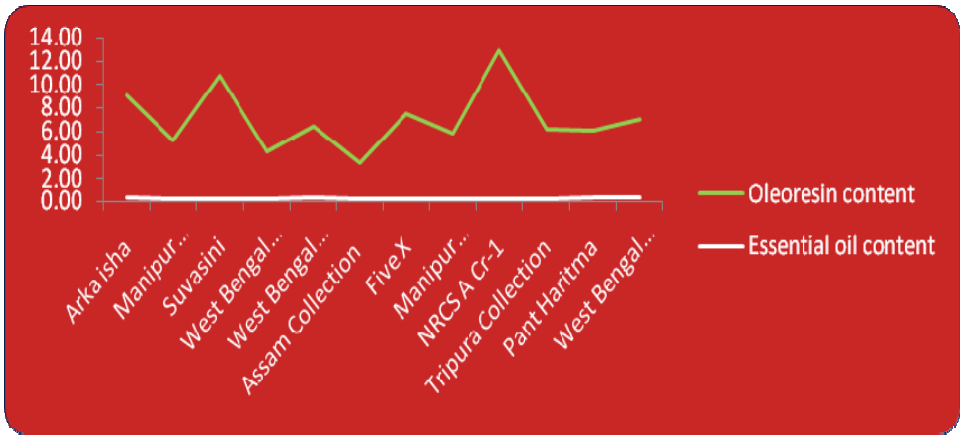

Fig. 12: Oleoresin content and essential oil content

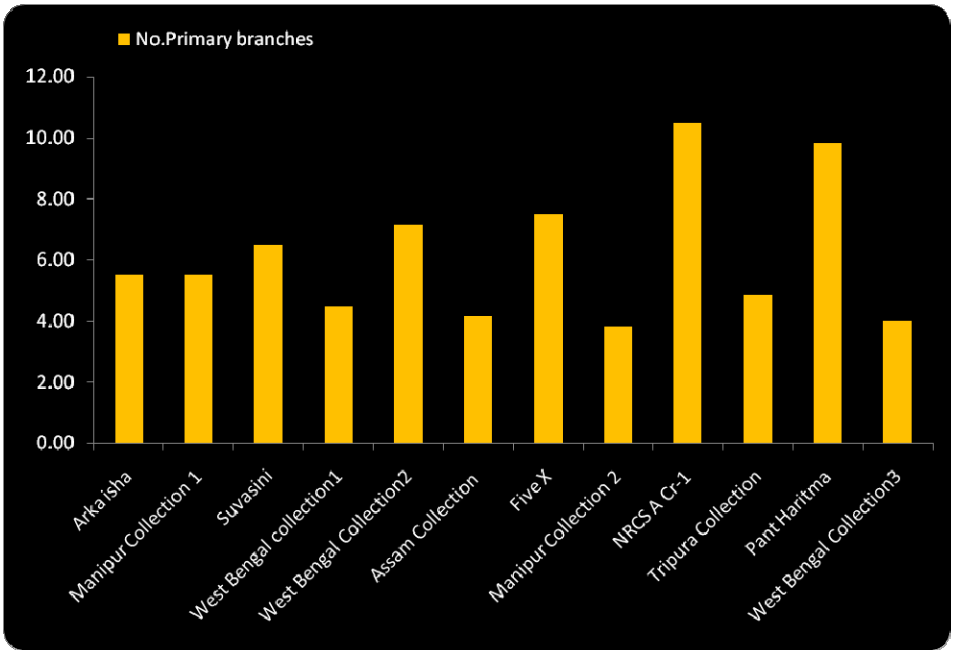

Fig. 13: Number of primary branches per plant

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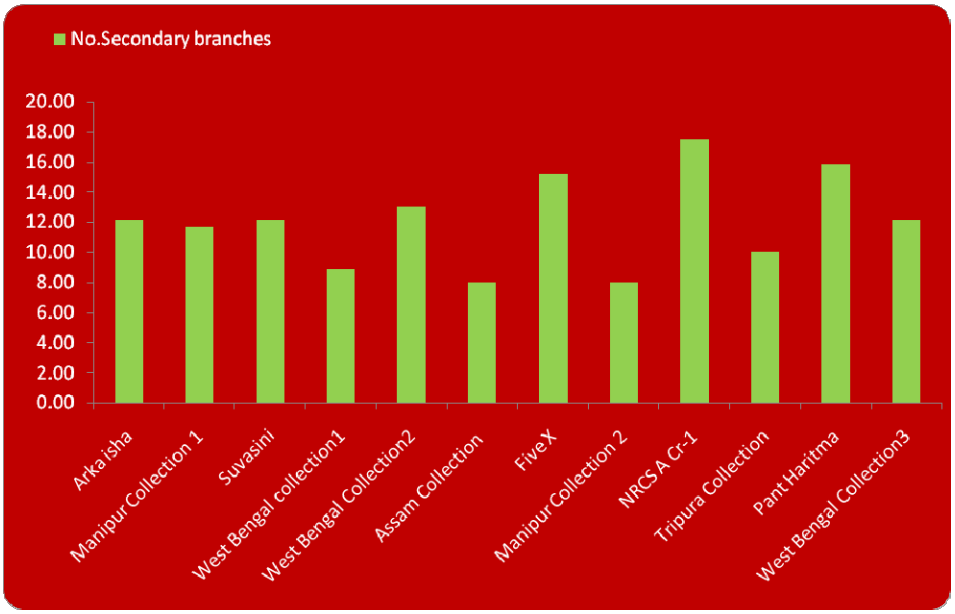

Fig. 14: Number of secondary branches per plant

collected from different sources were examined and yield component analyses were carried out to identify important coriander seed yield components.

4.2.1. Analysis of Genetic Diversity and Heritability:

The present study was initiated to examine the nature of variability in different characters of coriander germplasm.

Analysis of variance of eleven traits revealed that mean squares due to genotypes were highly significant (Table 7). The co-efficient of variation were below 10% for the characters like days to flowering, days to harvest, plant height, number of basal leaves, secondary branch, umbels per plant, umbellets per umbel, number of seeds per umbel, test weight and seed yield per plant during 1st year and 2nd year, excluding primary branch confirming the reliability of the experiment and also suggesting less G x E interactions. However, the co-efficient of variation was little bit high for the

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characters like primary and secondary suggesting moderate G x E interactions. Phenotypic co-efficient of variation (PCV) agreed closely with the genotypic co-efficient of variation (GCV) but the magnitude of PCV was higher than GCV for almost all the characters (Table. 8). Broad sense heritability values were higher (more than 90 %) for all the characters except secondary branch (89.16%). However, genetic advance (GA) expressed as percentage of mean was very high for the characters like Seed yield/plant, number of seeds/umbel, number of basal leaves, primary branch, and secondary branch and plant height. In other words, Seed yield per plant, Number of seeds per umbel, number of basal leaves, primary branch, secondary branch and plant height were characterised by high PCV, GCV, heritability and genetic advance. The results find support from the observations of Sanker *et al.* (1991), Sharma and Sharma (1989) and Singh *et al.* (2006).

The low heritability is being exhibited due to high environmental effects. High heritability accompanied with low genetic advance for the character like days to flowering, days to harvest, umbel per plant and test weight suggesting that this character is influenced due to favourable influence of environment rather than genotypes.

4.2.2 Correlation co-efficients:

Association analysis of different morphological characters with seed yield of coriander germplasm and their inter-relationships were investigated through the study of both phenotypic and genotypic correlation co-efficients.

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Table 9: Phenotypic and genotypic correlation coefficients of eleven characters of coriander in 1st year

		Days to flowering	Days to maturity	Plant height (cm)	No. basal leaves	No. Primary branches	No. Secondary branches	Umbels/ plant	Umbellets /umbel	No. seeds/umbel	Test weight	Seed yield/ plant
Days to flowering	p	**0.761****	0.702**	0.634**	0.672**	**0.863****	0.524**	0.609**	0.577**	0.311NS	0.409*
	G	**0.788****	0.760**	0.688**	0.690**	**0.891****	0.566**	0.660**	0.619**	0.335*	0.445**
Days to maturity	P		0.667**	0.582**	**0.798****	0.787**	0.657**	0.744**	**0.869****	0.226NS	**0.789****
	G		0.709**	0.616**	**0.839****	0.843**	0.708**	0.796**	**0.900****	0.239NS	**0.806****
Plant height	P			0.805**	0.745**	0.734**	0.749**	0.636**	0.718**	0.251NS	0.589**
	G			0.887**	0.804**	0.826**	0.807**	0.694**	0.806**	0.296NS	0.638**
No.basal leaves	P				0.555**	0.665**	0.725**	0.573**	0.579**	0.564**	0.554**
	G				0.595**	0.737**	0.804**	0.631**	0.608**	0.634**	0.582**
No.Primary branches	P					**0.868****	0.766**	0.677**	**0.833****	0.173NS	**0.803****
	G					**0.880****	0.846**	0.737**	**0.896****	0.183NS	**0.835****
No. Secondary branches	P						0.736**	0.679**	0.657**	0.341*	0.671**
	G						0.841**	0.773**	0.738**	0.379*	0.722**
Umbels/ plant	P							0.702**	0.657**	0.453**	**0.752****
	G							0.755**	0.717**	0.490**	**0.808****
Umbellets/ umbel	P								0.588**	0.562**	0.624**
	G								0.632**	0.597**	0.664**

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No. Seeds/ umbel	P									0.006NS	**0.813****
	G									0.017NS	**0.866****
Test weight	P										0.264 NS
	G										0.273 NS

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

Table 10: Phenotypic and genotypic correlation coefficients of eleven characters of coriander in 2nd year

		Days to flowering	**Days to maturity**	**Plant height(cm)**	**No. basal leaves**	**No. Primary branches**	**No. Secondary branches**	**Umbels/ plant**	**Umbellets/ umbel**	**No. seeds/umbel**	**Test weight**	**Seed yield/plant**
Days to flowering	P		**0.798****	**0.751****	0.713**	0.656**	**0.717****	0.540**	0.638**	0.609**	0.347*	0.478**
	G		**0.823****	**0.832****	0.776**	0.714**	**0.840****	0.600**	0.676**	0.645**	0.368*	0.511**
Days to maturity	P			0.714**	0.513**	**0.800****	0.705**	0.639**	0.740**	**0.860****	0.209 NS	**0.783****
	G			0.747**	0.549**	**0.827****	0.808**	0.681**	0.794**	**0.882****	0.216 NS	**0.787****
Plant height	P				0.785**	0.703**	0.672**	0.721**	0.647**	0.756**	0.325 NS	0.641**
	G				0.898**	0.766**	0.819**	0.815**	0.718**	0.813**	0.355*	0.672**
No.basal leaves	P					0.454**	0.493**	0.645**	0.556**	0.519**	0.563**	0.485**
	G					0.476**	0.631**	0.690**	0.588**	0.562**	0.600**	0.521**
No. Primary branches	P						0.876**	**0.772****	0.682**	**0.779****	0.194 NS	**0.823****
	G						0.969**	**0.849****	0.753**	**0.845****	0.200 NS	**0.842****
No. Secondary branches	P							0.699**	0.639**	0.611**	0.264 NS	0.687**
	G							0.879**	0.762**	0.747**	0.300 NS	0.762**
Umbels/ plant	P								0.632**	0.693**	0.403*	**0.765****

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	G							0.723**	0.735**	0.432**	**0.818****
Umbellets/ umbel	P								0.562**	0.632**	0.638**
	G								0.620**	0.678**	0.686**
No. Seeds/ umbel	P									0.013 NS	**0.843****
	G									0.005 NS	**0.880****
Test weight	P										0.265NS
	G										0.275NS

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

Table 11: Path analysis using phenotypic correlations of seed yield/plant on others (1st year)

	Days to flowering	**Days to maturity**	**Plant height(cm)**	**No. basal leaves**	**No. Primary branches**	**No. Secondary branches**	**Umbels/plant**	**Umbellets/umbel**	**No. seeds/ umbel**	**Test weight**	**Phenotypic correlation with yield**
Days to flowering	**-0.837**	-0.637	-0.587	-0.531	-0.563	-0.722	-0.438	-0.509	-0.483	-0.261	0.409*
Days to maturity	0.488	**0.641**	0.428	0.373	0.512	0.505	0.421	0.477	0.558	0.145	0.789**
Plant height	0.061	0.058	**0.087**	0.070	0.065	0.064	0.065	0.055	0.062	0.022	0.589**
No. Basal leaves	-0.034	-0.032	-0.044	**-0.054**	-0.030	-0.036	-0.039	-0.031	-0.031	-0.031	0.554**
No.Primary branches	0.080	0.095	0.089	0.066	**0.119**	0.104	0.092	0.081	0.100	0.021	0.803**
No. Secondary branches	0.471	0.430	0.401	0.363	0.474	**0.546**	0.402	0.371	0.359	0.186	0.671**
Umbels/ plant	0.026	0.032	0.037	0.035	0.037	0.036	**0.049**	0.034	0.032	0.022	0.752**
Umbellets/umbel	-0.124	-0.152	-0.129	-0.117	-0.138	-0.138	-0.143	**-0.204**	-0.120	-0.115	0.624**
No. Seeds/umbel	0.194	0.291	0.241	0.194	0.279	0.220	0.220	0.197	**0.335**	0.002	0.813**
Test weight	0.085	0.061	0.068	0.153	0.047	0.093	0.123	0.153	0.002	**0.272**	0.264 NS

Residual effect=0.09909, Direct effect=Bold diagonals, * Significant at 5%; **

Significant at 1% level

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Table 12: Path analysis using phenotypic correlations of seed yield/plant on others (2nd year)

	Days to flowering	Days to maturity	Plant height(cm)	No. basal leaves	No.Primary branches	No.Secondary branches	Umbels/plant	Umbellets/umbel	No. seeds/umbel	Test weight	Phenotypic correlation with yield
Days to flowering	**-0.645**	-0.515	-0.485	-0.460	-0.423	-0.463	-0.348	-0.412	-0.393	-0.224	0.478**
Days to maturity	0.426	**0.533**	0.381	0.274	0.426	0.376	0.341	0.395	0.459	0.112	0.783**
Plant height	-0.102	-0.097	**-0.136**	-0.107	-0.095	-0.091	-0.098	-0.088	-0.103	-0.044	0.641**
No. Basal leaves	0.140	0.101	0.155	**0.197**	0.089	0.097	0.127	0.109	0.102	0.111	0.485**
No.Primary branches	0.188	0.229	0.202	0.130	**0.287**	0.251	0.221	0.196	0.224	0.056	0.823**
No. Secondary branches	0.188	0.184	0.176	0.129	0.229	**0.262**	0.183	0.167	0.160	0.069	0.687**
Umbels/ plant	-0.010	-0.012	-0.013	-0.012	-0.014	-0.013	**-0.018**	-0.012	-0.013	-0.007	0.765**
Umbellets/ umbel	-0.138	-0.161	-0.140	-0.121	-0.148	-0.139	-0.137	**-0.217**	-0.122	-0.137	0.638**
No. Seeds/umbel	0.320	0.451	0.397	0.272	0.409	0.321	0.364	0.295	**0.525**	0.007	0.843**
Test weight	0.112	0.068	0.105	0.182	0.063	0.085	0.130	0.204	0.004	**0.323**	0.265 NS

Residual effect=0.09052, Direct effect=Bold diagonals, * Significant at 5%; ** Significant at 1% level

In the present study, eleven characters including growth and reproductive characters were recorded and their genotypic and phenotypic correlation co-efficient were analysed. The results were presented in Table 9 and 10. Phenotypic and genotypic correlation co-efficients, in general, agreed very closely. However, the genotypic correlations were higher than

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phenotypic correlations in most of the cases. These could occur when the genes governing

In the present study, eleven characters including growth and reproductive characters were recorded and their genotypic and phenotypic correlation co-efficient were analysed. The results were presented in Table 9 and 10. Phenotypic and genotypic correlation co-efficients, in general, agreed very closely. However, the genotypic correlations were higher than phenotypic correlations in most of the cases. These could occur when the genes governing two traits were similar and environmental factors played a small part in the expression of these traits. Out of eleven characters studied, days to flowering, days to maturity, plant height, number of basal leaves, primary branches, secondary branches, umbels per plant, umbellets per umbel, number of seeds per umbel show significant positive correlation co-efficient with seed yield per plant. Besides, test weight showed positive but non significant correlation with seed yield per plant. Such associationships with seed yield per plant have already been observed by Singh and Prasad (2006), Datta (2006), Vijayalatha and Chezhiyan (2004).

The inter-relationships among the characters exhibited that almost all correlation co-efficient were significantly positive. They also showed high genotypic correlations as well. These important inter-relationships were between days to flowering and days to maturity (0.761, 0.788), days to maturity and primary branches (0.789, 0.839), days to flowering and secondary branches (0.863, 0.891), number of primary branches and secondary branches (0.868, 0.880), days to maturity and number of seeds per umbel (0.869, 0.900), number of primary branches and number of seeds per umbel (0.833, 0.896) for phenotypic and genotypic respectively.

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The correlation analysis indicated the complex nature of relationships for the plant characters as for example, number of primary branches and number of seeds per umbel not only exhibited highly positive correlation co-efficient with seed yield per plant but they were also positively and significantly inter-related to each other. Hence, the selection on the basis of any of the significantly positive inter-related characters was expected to give a desired correlated response in other characters.

4.2.3 Path Co-efficient Analysis:

The complexity of character relationships among themselves and with seed yield per plant becomes evident from the discussion alone did not provide a comprehensive picture of relative importance of direct and indirect influences of each characters to the seed yield, as these traits were the resultant product of combined effects of various factors complementing or counteracting. In the present study, the phenotypic and genotypic correlation were partitioned into direct and indirect effects to identify relative importance of yield component towards seed yield per plant of coriander (Table 11 and 12).

Seed in coriander is important as this is utilized as spices throughout the world. Hence the direct effect and positive association with seed yield per plant was considered essential. Among the eleven yield component traits, days to maturity, plant height, primary branch, secondary branch, umbels per plant, number of seeds per umbel and test weight showed highly positive direct effect on seed yield per plant. This was the main cause of their positive association, although days to flowering, number of basal leaves, and umbellets per umbel showed negative association with seed yield per plant. The direct selection for these characters could be beneficial for yield improvement of coriander seed since these characters also showed positive correlation with seed yield per plant. The results are

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in conformity with the observations of Meena *et al.* (2014), Meena *et al.* (2014), Dyulgerov and Dyulgerova (2014)

Residual effects was very low (0.09909 and0.09052**)** suggesting inclusion of maximum seed yield influencing characters in the present analysis.

4.3 Genetic diversity of the genotypes through multivariate analysis

Prof. P.C. Mahalanobis (1936) of Indian Statistical Institute, Calcutta, developed the D^2 Statistic model to determine the divergence among population in terms of generalized group distance. It has been widely used in Psychometry and anthropometry for classificatory purpose. Later on, it has been successfully exploited in plant breeding. Multivariate analysis is a powerful tool in qualifying the degree of divergence between biological populations (genetic distance) and to assess the relative contribution of different components to the total divergence. Although, Mahalanobis's generalized distance as a measure of genetic distance occupy a unique place in plant breeding yet, as it happens in biology, several problems under the influence of random unpredictable changes due to environment, evade the direct grip of the concept well proven is more exact fields like mathematical components. It suggests the measuring the genetic distance through multivariate analysis over environment, to fortify its reliability. Genetic divergence of coriander using Mahalanobis's statistics was earlier studied by several workers Patel *et al.* (2000),Singh *et al.* (2002), Mengesha *et al.* (2011) and Fufa, (2013).

The present study aimed at analyzing the genetic divergence of 12 genotypes employing 11 important quantitative characters namely, days to flowering, days to maturity, plant height, number of basal leaves, number of primary branches, number of secondary branches, umbels per plant,

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umbellets per umbel, number of seeds per umbel, test weight and seed yield per plant.

The analysis of variance showedhighly significant differences among the 12 genotypes for all the eleven characters. This indicated that large variability existed among the genotypes and that further analysis of genetic divergence is reasonable. Considerable difference in coriander cultivars for all the characters were recorded earlier by *Meena et al.(*2014) , Patel *et al.* (2000), Singh *et al.* (2002), Mengesha *et al.* (2011), Singh *et al.* (2005) and Fufa, (2013).

Based on the degree of divergence (D^2 values) between any two genotypes a logical grouping of the genotypes with low D^2 value could be arrived at by Tocher's method as described byRao (1952).

Based on the determination of divergence, all the 12 genotypes could meaningfully be grouped into 5 clusters(Table-13).Cluster 1,2 and 3 had 3 genotypes each followed by cluster 4 which comprised of 2 genotypes, while cluster 5 had 1 genotypes.The grouping pattern of genotypes was observed to be random, indicating that geographical diversity and genetic divergence were unrelated. Therefore, the selection of genotypes for hybridization should be based on genetic divergence rather than geographic diversity

Table 13: Clustering of the genotypes

Cluster 1 (3)	Arka Isha, west Bengal collection-1, Tripura collection
Cluster 2 (3)	Manipur collection-1, Suvashini, Assam collection
Cluster 3 (3)	West Bengal collection-2, Five X, Pant Haritma
Cluster 4 (2)	Manipur collection-2, West Bengal collection-3
Cluster 5 (1)	NRCS A.Cr-1

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The intra and inter-cluster distance among 12 genotypes presentedin Table 14revealed that Cluster 1 showed the maximum intra-cluster value (21.603) indicating that genotypes included in this cluster are diverse. Cluster 5 showed the no intra-cluster value (0.00).

At inter-cluster level, minimum values was observed between Cluster 3 and 5 (17.449) indicating close relationship among the genotypes included in these clusters. The maximum inter-cluster values were observed between cluster 4 and 5 (44.383) followed by 43.753 between Cluster 2 and 5 which indicated that the genotypes included in these clusters had the maximum divergence. Hence, intermating between the genotypes included in these clusters was expected to give transgressive segregates in the advanced generation.

Table 14: Inter-and intra-cluster D-square values

Cluster	1	2	3	4	5
1	21.603	26.673	28.509	36.228	35.630
2		18.028	36.670	23.499	43.753
3			18.261	38.235	17.449
4				20.567	44.383
5					0.000

Considerable distances in cluster mean were observed for the characters like days to maturity, plant height, days to flowering, umbels per plant and number of seeds per umbel(Table 15). The maximum cluster mean was observed in cluster 5 for days to maturity and plant height followed cluster 3 on same character. These clusters could be regarded as useful sources of gene for important yield component traits.

The relative contribution of individual characters towards genetic divergence has been computed

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Plate 4: Diverse germplasms of Coriander

in terms of number of times it ranked first(Table 15).Seed yield per plant (83.33%) towards genetic divergence followed by test weight (6.06%), days to maturity (4.54%) and number of basal leaves (3.03%) showing thepossibility for selection of these characters.Similar findings have also

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been observed byPatel *et al.* (2000), *Meena et al.(2014), M*engesha *et al.* (2011).

Table 15: Cluster mean values for eleven characters of coriander

Characters	Cluster1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Percent contribution towards divergence
Days to flowering	54.444	51.444	65.944	61.25	77.167	0
Days to maturity	101.72	98.278	120.61	109.17	130.33	4.5455
Plant height	85.342	85.262	108.75	77.652	112.49	0
No. Basal leaves	5.722	4.556	7.444	5	6.333	3.0303
Primary branch	4.944	5.389	8.167	3.917	10.5	0
Secondary branch	10.333	10.611	14.667	10.083	17.5	0
Umbel/ plant	19.993	21.354	27.871	18.297	24.123	1.5152
Umbellets/umbel	3.949	4.61	5.783	5.098	6.12	0
No. Seeds/umbel	32.439	28.879	43.77	28.145	51.302	1.5152
Test weight	7.575	7.497	8.174	8.108	7.072	6.0606
Seed yield/plant	3.095	1.858	5.212	1.657	5.598	83.333

Keeping the genetic diversity and *per se* performance for yield and important yield components, 2 groups of genotypes have been selected.

Group 1 : NRCS ACr. 1

Group 2 : West Bengal collection-2, Five X, Pant Haritma

Inter-group crossing of the genotypes is expected to produce heterotic hybrids.

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