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Short Communication

Genetic diversity in fennel (*Foeniculum vulgare* Miller)

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Fennel (*Foeniculum vulgare* Miller), family '*Apiaceae*' is important for its seeds and essential oil. The seeds are also regarded as aromatic, carminative, emmenagogue, and stimulant and stomachic almost anywhere the spices are encountered [1, 2]. In the present study, genetic divergence among landraces was quantified by multivariate analysis with the objectives: (i) to assess the proximity of landraces thus classify them in different clusters/groups, (ii) to identify highly divergent clusters/promising genotypes for high seed and oil yield of better quality.

Thirty seven diverse landraces of fennel assembled from 17 different states of India i.e. UP (11, SF-1 to SF-8, SF-29 and SF-31), two each from M.P. (SF-9, 10), Uttaranchal (SF-11, 22), Punjab (SF-12, 13), Orissa (SF-14, 25), J&K (SF-15, 16), Haryana (SF-17, 27), M.S. (SF-18, 23), Rajasthan (SF-20, 36), W. Bengal (SF-24, 37), Gujarat (SF-28, 35); one each from A.P. (SF-19), Chattisgarh (SF-21), Himachal (SF-26), Assam (SF-30), Kerala (SF-32) and Bihar (SF-33) were maintained and evaluated in field trials for the eight economic traits in the three consecutive years (1999-2000 to 2001-2002). The plants were grown in randomized block design with two replications. Each treatment consisted of single row 4.00 m long and 50 cm apart (plant to plant distance was kept 50 cm). Observations were recorded on five randomly selected plants in each entry for all the three years and their means (three years) were utilized for statistical analysis.

Observations were recorded on the 8 economic traits: days to flowering (50 %), plant height (cm), umbels/plant, diameter of main stem, umbels on main stalk, seed yield/plot (g), oil content (%) and t-anethole content (%) in the oil. The pooled mean values of the three years (1999-2000 to 2001-2002) for all the eight characters were subjected to D^2-statistics and canonical analyses [3-5]. Highly significant differences (P = 0.01) for all of the eight traits, indicated the presence of considerable divergence among the 37 landraces of fennel crop. Genetic diversity among the 37 landraces was relatively large, although 27.03 % of the landraces could be grouped within one cluster I followed by clusters II and III (24.324 %), cluster IV (13.514 %) and cluster V (5.405 %). Only 2.703 % of the landraces were highly divergent forming two different clusters Cluster VI-VII (Table 1).

Landraces could be grouped in to seven clusters but enormous diversity among the landraces were indicated by wide range of D^2-value (D^2 = 213.743-54888.380). The mean intra- and inter-cluster D^2 values indicated the highest divergence between clusters designated V and VI (D^2 = 54519.64) followed by clusters designated V and VII. (D^2 = 53842.47). Divergence was also noted between clusters designated III and V (D^2 = 35810.44), IV and VI (D^2 = 25273.29) and between II and V (D^2 = 24817.03) in order. The clustering pattern was also confirmed by spatial distribution of landraces under the canonical analysis. The cluster V was divergent including two landraces SF-9 and SF-16 belonging to M.P. and Jammu and Kashmir states. The cluster VI and VII was also highly divergent and unique including only one accession each namely SF-31 and SF-36 belonging to U.P. and Rajasthan states. The cluster mean are also indicated high genetic diversity in the fennel landraces (Table 2). The diameter of main stem (1.00, 0.495) followed by width of umbels/plant (0.614, 0.304) and days to 50 % flowering (0.563, 0.279) at the primary axis (Z1) and the secondary axis (Z2), respectively were the largest contributors to genetic divergence. The least contributors to genetic divergence were t-anethole content % (0.347, 0.172) and oil content (-1.328, -0.658) at the both primary and secondary axis, respectively (Table 2). The character umbels/plant is the highest relative contributor and ranked I followed by umbels on main stalk ranked II and oil content (%) ranked III towards the total divergence, respectively (Table 2).

The distribution pattern of fennel landraces of diverse origin in a single cluster or same origin in different clusters for example: cluster I includes landraces collected from U.P., M.P., Punjab, Andhra Pradesh,

Table 1. Intra- and inter-cluster divergence (D^2) among seven clusters of fennel land races

Clusters/ landraces	I	II	III	IV	V	VI	VII	$\overline{D}^2$	Landraces included SF-1 to SF-37
I (10)	944.55	2429.81	6432.29	2285.83	14453.63	15227.28	13996.69	9137.59	1, 5, 7, 13, 19, 20, 22, 23, 24, 26
II (9)		1121.22	2498.40	6799.99	24817.03	7732.69	6798.54	8512.74	2, 4, 6, 11, 12, 15, 18, 27, 34
III (9)			1074.50	13213.64	35810.44	3129.72	2833.91	10653.07	3, 10, 25, 28, 30, 32, 33, 35, 37
IV (5)				650.57	6717.73	25273.29	24453.62	13124.02	8, 14, 17, 21, 29
V (2)					731.62	54519.64	53842.47	31693.49	9, 16
VI (1)						0.00	1298.14	17863.46	31
VII (1)							0.00	17203.90	36

$\overline{D}^2$ = Average D^2 values

Table 2. Mean cluster values for measured characters, Z1 and Z2 - vectors and relative contribution (%) of fennel landraces

Clusters	Days to flower (50%)	Plant height (cm)	Umbels/ plant	Diameter of main stem (cm)	Umbels on main stalk	Seed yield (g/plant)	Oil content (%)	t-anethole content (%)
I	96.63	132.57	12.13	1.22	37.15	164.78	2.45	65.51
II	97.98	127.85	12.52	1.78	40.65	132.16	2.22	61.18
III	108.24	120.69	12.33	1.33	37.74	95.46	1.42	63.98
IV	94.07	129.80	12.63	1.37	45.60	228.06	2.35	65.96
V	91.25	131.08	24.00	1.42	38.25	327.91	1.95	67.08
VI	131.67	132.00	29.83	1.46	49.00	32.75	1.35	55.61
VII	122.50	118.50	13.50	1.05	22.50	40.40	1.58	67.67
Z1-Vector	0.563	0.559	0.614	1.000	0.166	0.395	−1.328	0.347
Z2-Vector	0.279	0.277	0.304	0.495	0.082	0.196	−0.658	0.172
Re. (%)	2.060	1.505	7.64	2.336	2.932	0.851	2.589	1.444
Rank	Vth	VIth	Ist	IVth	IInd	VIIIth	IIIrd	VIIth

Re. - Relative contribution (%) towards total divergence

Rajasthan, Uttaranchal, Maharashtra, W. Bengal and Himachal states indicates that genetic diversity observed within fennel landraces was not related to geographic origin. Noted differences in plant characters probably occurred due to migration of genetic materials/genotypes from one places to other or selection, mutations, hybridization and genetic drift in the fennel genotypes. Thus, in this set of fennel landraces to be used as parents for hybridization or other genetic improvement programme should be selected on the basis of the quantified degree of divergence as opposed to geographic origin. The landraces No. SF 31, SF 36 of the cluster VI and VII followed by SF 9 and SF 16 of the cluster V were unique and very genetically diverse. These landraces can be exploited directly or in further genetic improvement programme of fennel crop.

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