The Pharma Innovation Journal 2020; 9(4): 160-164

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(4): 160-164

www.thepharmajournal.com
Received: 14-02-2020
Accepted: 16-03-2020

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Genetic variability studies in fennel (*Foeniculum vulgare* L.)

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Abstract
The present investigation was conducted during October 2014 - May 2015 at Main Experimental Station of Vegetable Science, Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodha (U.P.). The field experiment was laid out in Augmented Block Design with 60 genotypes along with two checks in six blocks accomodating ten genotypes and two checks in each block. The characters studied were days to 50% flowering, Plant height (cm), number of branches per plant, number of umbels per plant**,** number of umbellets per umbel, number of grains per umbellets, days to maturity, weight of grains per umbel (g), 1000 seed weight(g), seed yield per plant (g) and Seed yield (q/ha). Data were analyzed statistically for their mean, range, coefficient of variation, heritability, genetic advance as per cent of mean and genetic divergence using non-heirarchical euclidean cluster analysis. Analysis of variance for the design of experiment revealed highly significant differences among genotypes for all the characters except branches per plant (0.35*) and test weight (0.33*). Based on mean performance for yield and yield components, the NDF-46 (58.80g), NDF-51 (52.83g), NDF-5 (52.63g), NDF-45 (49.90g) and NDF-49 (48.90g) were identified as most promising genotypes for seed yield per plant. The highest genotypic and phenotypic coefficients of variances were observed for umbels per plant (20.38% and 20.45%) and lowest for days to maturity (1.571% and 1.770%, respectively). High heritability coupled with high genetic advance in percent of mean were observed for Umbels per plant, yield per plant, seed yield (q/ha) and weight of grains per umbel indicating the importance of additive gene effects for these traits.

Keywords: Fennel, *Foeniculum vulgare,* variability, heritabiltity

Introduction
Fennel *(Foeniculum vulgare* Mill.) chromosome no. 2n=2x= 22 is one of the most eminent medicinal and aromatic plant belonging to the family Apiaceae (Umbelliferae). It is a stout, glabrous, biennial or perennial – umbelliferous herb with tiny shiny yellow flowers and feathery leaves. It is generally considered indigenous to the shores of Mediterranean Sea region but has become widely naturalized in many parts of the world, especially on dry soils near the sea coast and on the river banks

Fennel is a pleasantly aromatic and flavourful herb with culinary and medicinal uses. Its seeds are anise like in aroma and are used as flavourings soups, sauces, pastries, confectionaries, baked goods, meat and fish dishes, ice-cream, cordials, alcoholic beverages and in seasoning pickles. The leaves are used in fish sauces and for garnishing while leaf stalks are also used both as vegetables and salad. The bulb, foliage and seeds of the fennel plant are widely used in many of the culinary traditions of the world.

The volatile oil in Indian fennel seed ranged from 0.7-1.2%. East European fennel seeds have been reported to contain 4.0-6.0% oil. Fennel is further found to be good source of minerals like Ca, Fe, Mg, K, Na, and Zn as well Vitamin- A and Niacin and phytate content varies from 11.35-13.10 mg/g. The active principles of fennel oil are anethole, limonene and fenchon.

Adequate knowledge on variability, genetic divergence, character association and the extent of contribution of each character to fruit yield and fruit biochemical quality traits is a prerequisite to plan appropriate breeding programme and evolve high yielding cultivars or hybrids with suitable traits. In this investigation experiments were conducted to evaluate the available germplasm for variability and divergence and to understand the performance of genotypes in terms of fruit quality characters. This facilitates identification of promising genotypes for use in further breeding programmes.

Material and methods
Experiments were conducted at the Main Experiment Station (Vegetable Research Farm),

Department of Vegetable Science, Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Faizabad (U.P.) India. 62 lines (60 test genotypes + 2 checks) of fennel germplasm maintained in All India Co-ordinated Research Project on Spices under Department of Vegetable Science, NDUA&T, Kumarganj, Faizabad were taken for this investigation. The experiment was laid out in a Augmented Block Design which was distributed in six blocks each containing 10 genotypes an two checks. 5 plants in each plot were tagged randomly for recording the data. All the cultural operations like nursery raising, main field preparation, transplanting, fertilization, irrigation, weeding, plant protection etc. were carried out as per the recommendations in order to raise a successful crop. Days to 50% flowering, days to maturity, plant height (cm), number of branches per plant, number of umbel per plant, number of umbellet per umbel, number of grains per umbellet, weight of grains per umbel (g), 1000 seed weight (g), seed yield per plant (g), seed yield (q/ha) parameters were recorded for analysis with the help of proper statistical tool.

Results

The mean performance of genotypes with respect to all eleven characters in fennel are presented in Table 2. The days to 50% flowering varied from 92.03 (NDF-31) to 111.03 (NDF-39) With General Mean of 101.00 days. Out of 34 genotypes, top five genotypes NDF-17, NDF-5, NDF-44, NDF- 46, NDF-18 were found significantly superior than best check RF-101 (101.50) days for this trait. Plant height (cm) varied from 126.79 (NDF-1) to 182.65 (NDF-27) with general mean of 148.17. Out of 10 genotypes, top five genotypes NDF-3, NDF-43, NDF-13, NDF-42, and NDF-50 were found significantly superior than best check RF-101 (140.32) for this trait. Branches per plant varied from 5.34 (NDF-22) to 11.28 (NDF-45) with general mean of 8.14. Out of 37 genotypes, top five genotypes NDF-39, NDF-6, NDF-26, NDF-37, and NDF-55 were found significantly superior than best check RF-101 (7.70) for this trait. Umbels per plant varied from 41.78 (NDF-13) to 112.90 (NDF-26) with general mean of 80.48. Out of 20 genotypes, top five genotypes NDF-49, NDF-32, NDF-56, NDF-31, and NDF-51 were found significantly superior than best check NDF-12 (89.33) for this trait. Umbellets per umbel varied from 19.69 (NDF-8) to 36.80 (NDF-46) with general mean of 26.74. Out of 30 genotypes, top five genotypes NDF-51, NDF-45, NDF-49, NDF-5, and NDF-33 were found significantly superior than best check RF-101 (26.21) for this trait. Grains per umbellets varied from 22.97 (NDF-57) to 40.03 (NDF-47) with general mean of 29.18. Out of 26 genotypes, top five genotypes NDF-46, NDF-37, NDF-12, NDF-26, and NDF-16 were found significantly superior than best check NDF-12 (29.00) for this trait. Days to maturity ranges from 213.78 (NDF-19) to 233.79 (NDF-40) with general mean of 224.03. Out of 13 genotypes, top five genotypes NDF-54, NDF-6, NDF-53, NDF-20 and NDF-60 were found significantly superior than best check RF-101 (219.93) for this trait. Weight of Grains per umbel varied from 0.51(NDF-10) to 0.97 (NDF-26) with general mean of 0.71. Out of 11 genotypes, top five genotypes NDF-27, NDF-40, NDF-6, NDF-25, and NDF-34 were found significantly superior than best check NDF-12 (0.81) for this trait. Test Weight varied from 4.65 (NDF-14) to 7.73 (NDF-53) with general mean of 6.48. Out of 12 genotypes, top five genotypes NDF-40, NDF-19, NDF-22, NDF-34, and NDF-42 were found significantly superior than best check RF-101 (7.20) for this trait. Seed yield plant varied from 29.53 (NDF-17) to 58.80 (NDF-46) with general mean of 42.14. Out of 18 genotypes, top five genotypes NDF-51, NDF-5, NDF-45, NDF-49, and NDF-24 were found significantly superior than best check NDF-12 (45.00) for this trait. Seed yield (q/ha) varied from 9.41 (NDF-13) to 17.51 (NDF-46) with general mean of 13.03. Out of 17 genotypes, top five genotypes NDF-5, NDF-51, NDF-45, NDF-49, and NDF-52 were found significantly superior than best check NDF-12 (13.90) for this trait.

The phenotypic (PCV) and genotypic (GCV) coefficients of variability for all the characters are presented in Table 3. The phenotypic coefficient of variation was estimated on the basis of sixty two genotypes for eleven characters *viz.*, umbels per plant (20.450%) showed highest PCV followed by weight of grains per umbel (13.055%), yield per plant (12.649%), seed yield q/ha (11.910), umbellets per umbel (11.765%), branches per plant (11.739%), grains per umbellets (11.382%), test weight (9.974%) and plant height (6.052%). the remaining two characters *viz.*, days to 50% flowering and days to maturity showed low value. The data on phenotypic coefficient of variation indicated that there is a greater scope of selection for the characters that showed high range of PCV and the characters which were showing low range are least effective. The genotypic coefficient of variation was estimated on the basis of sixty two genotypes for eleven characters *viz.*, umbels per plant (20.381%) showed highest GCV followed by weight of grains per umbel (12.872%), yield per plant (12.554%), seed yield q/ha (11.856), umbellets per umbel (11.615%), branches per plant (11.529%), grains per umbellets (11.226), test weight (9.590), and the remaining three characters days to 50% flowering, plant height and days to maturity expressed low GCV.

Heritability gives an idea of transmissibility of a character from parent to offspring. The estimates of heritability in broad sense (h^2_{bs}) showed considerable variation for different characters (Table.3). The value of h^2_{bs} ranged from 78.77 (days to maturity) to 99.32% (umbel per plant). Higher estimates of heritability were also observed for seed yield (q/ha) (99.10%) followed by seed yield per plant (98.51%), grains per umbellets (97.97%), umbellets per umbel (97.46%), weight of grains per umbel (97.22%), branches per plant (96.45%), plant height (93.65%), days to 50% flowering (92.83%) and Test weight (92.45) while moderate heritability was observed for days to maturity.

The highest estimates of genetic advance along with high heritability clearly indicates the possibility of improvement through selection. Genetic advance in percent of mean exhibited considerable variation for different characters. The genetic advance in percent of mean ranged from (3.681%) days to maturity to (53.623%) umbel per plant. Weight of grains per umbel (33.507%), yield per plant (32.894%), seed yield (q/ha) (31.159%), umbellets per umbel (30.272%), branches per plant (29.890%) and grains per umbellet (29.440%) showed higher genetic advance in per cent of mean. Rest of the characters showed low genetic advance in per cent of mean.

Table 1: Analysis of variance (Augmented Block Design) for eleven characters in fennel germplasm.

Characters	Sources of variation		
	Blocks	Check	Error
	5 (d.f)	1 (d.f)	5
Days to 50% flowering	3.41**	110.02**	0.78
Plant height (cm)	69.54**	135.54**	5.11
Branches / plant	0.35*	0.36*	0.03
Umbels / plant	1513.12**	277.06**	1.82
Umbelletes / umbel	19.04**	5.21**	0.25
Grains / Umbellets	9.23**	9.84**	0.22
Days to maturity	15.59**	208.68**	3.34
Weight of grains / umbel (g)	0.01**	0.00	0.00
Test weight (g)	0.33*	0.80**	0.03
Seed yield / plant (g)	90.073**	12.00**	0.42
Seed Yield/ ha (q)	7.18**	0.48**	0.02

* Significant at 5% probability level, ** significant at 1% probability level

Table 2: Mean Performance of 62 Genotypes of Fennel

Characters / Genotypes	Days to 50% flowering	Plant height (cm)	Branches/plant	Umbels/ plant	Umbellet/ umbel	Grains / Umbellets	Days to maturity	Weight of grains/ umbel (g)	Test weight (g)	Seed yield/ Plant (g)	Seed yield /ha (q)
NDF- 1	99.028	126.794	8.296	79.030	23.561	30.979	227.937	0.655	6.217	42.130	12.250
NDF- 2	101.362	140.794	9.296	65.360	26.291	33.079	221.937	0.615	6.517	38.330	11.420
NDF- 3	95.028	127.794	8.296	47.030	27.661	26.949	226.937	0.675	6.117	37.430	11.270
NDF- 4	100.028	145.794	7.626	57.360	21.091	31.379	218.937	0.645	5.817	43.210	12.500
NDF- 5	108.028	153.794	8.296	82.360	32.461	29.979	222.937	0.815	6.817	52.630	16.340
NDF- 6	98.362	151.124	10.296	78.030	24.621	31.879	215.937	0.905	7.317	47.310	14.650
NDF- 7	99.362	160.124	7.296	63.030	27.661	30.279	229.937	0.605	7.017	43.530	12.120
NDF- 8	102.028	154.794	7.626	59.360	19.691	24.479	230.937	0.635	6.317	35.730	10.740
NDF- 9	104.028	145.794	7.296	57.030	25.661	29.779	226.937	0.575	7.217	37.430	11.250
NDF -10	97.362	156.794	8.296	69.360	21.331	27.979	226.277	0.515	5.817	38.830	11.630
NDF- 11	101.028	155.329	6.211	51.780	26.441	27.449	222.437	0.780	6.352	35.830	11.690
NDF- 12	97.694	147.999	7.211	85.110	28.041	36.019	228.437	0.720	7.152	45.730	14.570
NDF- 13	98.028	132.999	6.541	41.780	23.611	26.349	227.437	0.660	6.252	29.930	9.410
NDF- 14	99.694	137.329	7.541	57.110	22.671	28.149	228.777	0.590	4.652	32.510	10.410
NDF- 15	102.694	148.999	8.541	76.110	24.611	23.949	226.777	0.630	5.952	42.430	12.940
NDF- 16	104.694	160.329	7.541	52.780	27.641	34.249	221.437	0.650	6.652	39.330	11.840
NDF- 17	94.028	149.999	8.211	44.110	27.281	25.049	220.437	0.640	5.352	29.530	9.570
NDF- 18	96.028	154.999	7.211	53.780	25.381	26.019	224.437	0.620	5.652	33.830	10.390
NDF- 19	96.694	158.329	9.211	59.110	26.281	30.149	213.777	0.730	7.452	35.230	11.560
NDF -20	102.028	142.329	8.541	67.780	23.671	25.349	217.437	0.760	6.452	36.730	11.220
NDF- 21	103.861	139.984	8.346	79.230	22.316	32.599	223.772	0.820	5.847	41.760	12.140
NDF- 22	101.861	150.984	5.346	60.900	24.986	27.199	220.772	0.850	7.447	43.060	12.730
NDF- 23	99.861	152.654	8.676	86.230	25.986	30.899	221.772	0.790	6.847	43.660	13.290
NDF- 24	97.195	171.984	7.676	94.900	28.176	27.869	222.772	0.750	7.347	48.660	14.150
NDF- 25	100.861	147.654	8.346	99.230	24.786	28.999	219.112	0.890	5.747	38.960	12.040
NDF- 26	104.861	166.654	9.676	112.900	22.116	34.869	221.112	0.970	5.847	40.730	14.720
NDF- 27	102.195	182.654	8.676	83.230	28.346	26.199	226.772	0.920	5.647	44.530	13.150
NDF- 28	98.195	145.654	7.346	69.900	30.316	28.899	227.772	0.760	6.447	42.830	13.000
NDF- 29	103.861	159.984	9.346	73.900	25.616	28.999	230.772	0.680	6.247	45.930	13.620
NDF -30	99.195	147.654	7.676	94.900	25.176	25.399	224.772	0.670	5.847	42.030	12.950
NDF- 31	92.028	152.579	7.436	102.855	26.516	28.789	224.792	0.575	6.927	43.760	13.520
NDF- 32	97.694	146.579	8.766	104.855	25.556	26.889	230.792	0.625	6.227	46.660	14.720
NDF- 33	102.694	150.579	8.436	93.855	32.386	30.289	224.792	0.825	6.527	41.960	13.210
NDF- 34	99.694	147.909	7.766	101.525	28.886	28.889	219.792	0.885	7.427	35.460	13.610
NDF- 35	100.028	143.909	7.436	85.525	24.986	26.789	221.792	0.705	6.627	39.760	12.590
NDF- 36	103.694	138.579	8.766	80.525	23.716	24.589	224.792	0.675	6.827	31.660	10.840
NDF- 37	106.694	147.579	9.436	91.855	25.386	36.189	226.792	0.615	7.227	45.590	14.190
NDF- 38	106.028	142.909	7.766	89.525	29.556	27.089	227.792	0.655	5.927	38.490	12.240
NDF- 39	**111.028**	140.579	10.436	84.525	26.986	25.989	219.792	0.645	5.327	33.890	10.590
NDF -40	103.028	148.909	8.436	68.525	27.916	31.489	**233.792**	0.915	7.527	40.390	12.360
NDF- 41	99.195	152.219	8.281	78.430	24.331	25.569	228.947	0.745	5.422	32.530	10.870
NDF- 42	99.861	134.219	7.281	62.430	26.631	27.469	222.607	0.775	7.422	40.430	12.370
NDF- 43	97.195	128.889	7.281	77.430	24.201	30.169	223.607	0.695	6.822	42.830	12.830
NDF- 44	95.195	143.219	7.611	96.760	29.271	27.369	224.607	0.675	6.322	46.700	14.300
NDF- 45	98.195	151.219	11.281	99.430	32.571	28.069	225.947	0.725	6.522	49.900	15.670
NDF- 46	95.861	158.889	8.281	95.430	36.801	36.969	226.607	0.785	7.022	58.800	17.510
NDF- 47	103.861	153.889	9.281	98.430	26.801	40.039	219.607	0.645	6.722	48.100	14.570
NDF- 48	102.861	147.889	8.611	84.760	31.871	30.669	227.607	0.655	6.122	44.700	13.680
NDF- 49	99.861	143.889	7.281	107.760	32.571	27.169	228.947	0.685	7.222	48.900	15.400
NDF -50	105.195	135.219	7.611	100.430	27.241	32.369	228.607	0.725	6.522	44.000	13.520
NDF- 51	101.195	140.064	6.741	102.315	35.616	32.874	224.437	0.845	7.037	52.830	16.340

NDF- 52	105.195	145.394	9.411	87.315	30.746	27.974	219.777	0.745	**7.337**	46.560	14.990
NDF- 53	101.861	153.064	7.741	86.315	26.346	25.574	216.437	0.665	**7.737**	47.860	14.490
NDF- 54	102.195	154.064	8.411	88.315	29.386	30.674	215.777	0.685	6.237	44.360	13.740
NDF- 55	98.861	148.064	9.411	101.315	24.946	27.074	223.437	0.605	6.837	42.660	13.320
NDF- 56	98.195	140.394	7.741	103.315	28.516	30.274	224.437	0.565	5.737	44.560	13.850
NDF- 57	102.861	152.064	7.411	83.315	27.816	22.974	219.437	0.625	5.337	40.760	12.910
NDF- 58	104.195	146.064	8.741	79.315	25.716	26.674	225.437	0.705	5.937	45.860	13.410
NDF- 59	107.195	150.064	7.741	96.645	25.916	32.774	223.777	0.775	6.237	48.560	14.850
NDF -60	102.195	142.394	8.411	85.315	24.416	31.874	217.777	0.735	6.637	46.760	14.630
NDF- 12(CH)	107.556	147.050	7.352	89.330	24.897	29.005	228.277	0.810	6.683	45.000	13.900
RF-101 (CH)	101.500	140.328	7.700	79.720	26.215	27.193	219.937	0.800	7.200	43.000	13.500
Mean	101.001	148.174	8.141	80.486	26.745	29.181	224.039	0.715	6.484	42.146	13.034
SD	3.683	9.751	1.012	17.544	3.320	3.425	4.300	0.100	0.672	5.764	1.680
SE	0.468	1.238	0.129	2.228	0.422	0.435	0.546	0.013	0.085	0.732	0.213
C.V.%	3.647	6.581	12.430	21.798	12.412	11.739	1.919	13.978	10.360	13.677	12.890

Table 3: Estimates of Range, general mean, genotypic and phenotypic variance, coefficient of variation, heritability, genetic advance and genetic advance in per cent of mean for 10 characters of fennel germplasm.

Characters	Range		General mean	Coefficient of variation (%)	PCV (%)	GCV (%)	Heritability (%)	Genetic advance	Genetic advance in per cent of mean
	Min.	Max							
Days to 50% flowering	92.028	111.028	101.001	3.647	3.287	3.167	92.83	8.126	8.055
Plant Height (cm)	126.794	182.654	148.174	6.581	6.052	5.857	93.65	22.196	14.966
Branches / plant	5.346	11.281	8.141	12.430	11.739	11.529	96.45	2.439	29.890
Umbels /plant	41.780	112.900	80.486	21.798	20.450	20.381	99.32	43.086	53.623
Umbellets /umbel	19.691	36.801	26.745	12.412	11.765	11.615	97.46	8.108	30.272
Grains /Umbellets	22.974	40.039	29.181	11.739	11.382	11.266	97.97	8.601	29.440
Days to maturity	219.937	233.792	224.039	1.919	1.770	1.571	78.77	8.247	3.681
Weight of grains/ umbel (g)	0.515	0.970	0.715	13.978	13.055	12.872	97.22	0.238	33.507
Test weight (g)	4.652	7.737	6.484	10.360	9.974	9.590	92.45	1.574	24.344
Yield /plant (g)	29.530	58.800	42.146	13.677	12.649	12.554	98.51	13.843	32.894
Seed yield (q/ ha)	9.410	17.510	13.034	12.890	11.910	11.856	99.10	4.054	31.159

Discussion

The analysis of variance for augmented design revealed highly significant differences among the checks for all the characters, except weight of grains per umbel. The assessment of existing variability in fennel germplasm and identification of superior genotypes for different characters were done by comparing the test genotypes with check and with best genotypes for each character using least significant difference values. The nature of associations among characters was studied by using heritability in broad sense and genetic advance in percent of mean (Hanson, 1956) [7], by using simple correlations (Searle, 1961) [14], path-coefficient analysis and Non–hierarchical euclidean cluster analysis (Beale, 1969; Spark, 1993) [5, 18] showed existence of variability among sixty two genotypes which validated by further statistical and genetical analyses

In order to evaluate the germplasm collection the mean of sixty two genotypes for eleven characters is presented in Table 2. A very wide range of variation in mean performance of genotypes was observed for all the characters under study. The comparison of mean performance of sixty two genotypes for eleven traits, using least significant differences revealed existence of very high level of variability in the germplasm collection.

The estimate of phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation for the characters, which is an indicator of additive effect on the expression of the character and selection must be done in these character for improvement. The phenotypic and genotypic coefficients of variation were to assess the nature and magnitude of existing variability in the germplasm.

The estimate of PCV and GCV indicated the fairly high degree of variability for umbels per plant (20.45% and 20.38%), weight of grains per umbel (13.05% and 12.87%), yield per plant (12.64% and 12.55%) and seed yield (q/ha) (11.91% and 11.85%). The phenotypic and genotypic coefficient of variation was also high for umbellets per umbel, branches per plant, grains per umbellet, test weight and plant height. The remaining two characters *viz.*, days to 50% flowering (3.28% and 3.16%) and days to maturity (1.77% and 1.57%) showed low value. The data on phenotypic coefficient of variation indicated that there is a greater scope of selection for the characters that showed high range of PCV and the characters which were showing low range are least effective where as genotypic coefficient of variation indicated possibility of obtaining very high selection response in respect of these traits. This is in accordance with the findings reported by Agnihotri *et al.*(1997) [3], Srivastava *et al.* (2000) [19], Yudhvir *et al.* (2002) [21], Agrawal *et al.* (2003) [3], Rajput and singh (2003) [12], Shukla *et al.* (2003) [16], Gupta *et al*. (2005) [6], Singh and Shastri (2006) [17], Lal *et al.*(2006) [8], Meena *et al.*(2010) [9], Abhay and Sastry (2011) [1], Yadav *et al.* (2013) [20] and Sharma *et al.* (2015) [15].

Genetic variability is the raw material on which selection acts to bring improvement in genetic architecture of plant. Heritability (h^2) and genetic advance in percent of mean acts as direct selection parameters provide index of transmissibility of traits which gives indication about the effectiveness of selection in improving the characters. However, the degree of improvement attained through selection is not only depending upon heritability but also on the amount of genetic variation present in breeding population and extent of the selection pressure applied by the breeder. The estimates of heritability in broad sense were higher for all the characters.

In the present investigation, the estimates of heritability in broad sense were higher for umbels per plant followed by seed yield (q/ha), seed yield/plant, grains per umbellet, umbellets per umbel, weight of grains/umbel, branches per plant, days to 50% flowering and test weight, while moderate

heritability was observed for days to maturity.

The highest genetic advance was expressed for umbels per plant followed by plant height and seed yield per plant, while lowest genetic advance was showed for weight of grains per umbel followed by test weight and branches per plant.

The genetic advance in percent of mean was highest in case of umbels per plant, weight of grains per umbel and seed yield per plant. However, low genetic advance in percent of mean was observed in days to maturity followed by days to 50% flowering and plant height.

The findings of present study are in agreement with those of Sanker and Khader (1991) [13], Ali *et al.* (1993) [4], Agnihotri *et al.* (1997) [3], Shukla *et al.*(2003) [16], Rajput and Singh (2003) [12], Gupta *et al.* (2005) [6], Lal *et al.* (2007), Patel *et al.* (2008) [10], Meena *et al.* (2010) [9], Abhay and Sastry (2011) [1], Yadav *et al.* (2013) [20].

Conclusion

Based on overall findings of the present investigation, it was concluded that there was a wide range of variation among the lines of fennel germplasm for all the characters indicating that considerable scope existed for the improvement of fennel cultivars through selections. Genetic parameters in association with correlation study indicated that for selection of superior genotypes, primary emphasis should be given on umbels per plant, umbellets per umbel, seed yield per plant, test weight and seed yield (q/ha). Out of sixty genotypes and two checks, NDF-46, NDF-5, NDF-51, NDF-45, NDF-49, NDF-53 NDF-52 from NDUA&T, Kumarganj. Faizabad (U.P) were found superior for yield and these germplasm may be recommended for large scale cultivation among the farmers after proper testing through multilocational yield trials and these superior genotypes can be used as donors in breeding programme.

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