Journal of Spices and Aromatic Crops
Vol. 22 (2) : 203–208 (2013)
www.indianspicesociety.in/josac/index.php/josac

Indian Society for Spices

Variability studies in fennel (*Foeniculum vulgare* Mill.)

P S Yadav*, V P Pandey & Y Yadav

Department of Vegetable Science, N.D. University of Agriculture & Technology, Kumarganj, Faizabad-224 229, Uttar Pradesh, India.
**E-mail: premvegetable@gamil.com*

Received 11 May 2012; Revised 27 August 2012; Accepted 2 February 2013

Abstract

Analysis of variability carried out for nine characters in 25 diverse genotypes of fennel (*Foeniculum vulgare*) revealed high genotypic and phenotypic coefficient of variations for seed yield plant^{-1}, weight of grains umbel^{-1}, number of umbels plant^{-1}, number of branches plant^{-1}, number of umbellet umbel^{-1} and plant height. Heritability estimates were high for test weight, weight of grains umbel^{-1}, seed yield plant^{-1}, number of umbel plant^{-1}, plant height and number of umbelletes umbel^{-1}. Higher genetic advance as per percentage of mean was recorded for seed yield plant^{-1}, weight of grains umbel^{-1}, number of umbels plant^{-1}, number of branches plant^{-1}, number of umbelletes umbel^{-1}, plant height and test weight. The plant height, days to 50% flowering, number of branches plant^{-1}, number of umbels plant^{-1}, number of umbellets umbel^{-1} and weight of grains umbel^{-1} exhibited positive and significant correlation with seed yield. Path coefficient analysis revealed that days to maturity had highest direct effect on seed yield followed by days to 50% flowering and number of umbels plant^{-1}. Therefore, greater emphasis should be given on these characters while selecting for higher yield and related traits.

Keywords: fennel, *Foeniculum vulgare*, genetic advance, heritability, variability

Very few efforts have been made to improve fennel (*Foeniculum vulgare* Mill.) through genetic manipulation. Since most of the yield attributing characters are quantitatively inherited and highly affected by environment it is difficult to judge whether the observed variability is heritable or not. The primary parameters *viz*., genotypic and phenotypic coefficient of (GCV and PCV, respectively) variations, genetic advance, genetic gain and heritability are useful in understanding the nature of inheritance of different traits. Therefore, the present study was undertaken to elicit information on the nature and magnitude of variability present in some morphological characters in fennel.

The study was conducted on 25 diverse genotypes (Table 1) collected from the germplasm maintained at the Main Vegetable Research Station, Narendra Deva University of Agriculture & Technology, (Narendra Nagar), Kumarganj, Faizabad (U.P.). The experiment was laid out in a randomized block design with three replications during *Rabi* 2008–09.

Each entry was grown in a single row of two meter length having an inter and intra row spacing of 60 cm × 40 cm. The observations were

Table 1. Name, source and collection year of the fennel genotypes

Name of genotypes	Source of genotypes	Collection year
NDF-36	Faizabad	2003
NDF-37	Paraspur, Gonda	2003
NDF-38	Balrampur	2004
NDF-39	Barabanki	2005
NDF-40	Varanasi	2006
NDF-41	Tarabganj. Gonda	2006
NDF-42	Tarabganj. Gonda	2006
NDF-43	Hariya, Basti	2006
NDF-44	Hariya, Basti	2006
NDF-45	Jaunpur	2004
NDF-46	Gazipur	2004
NDF-47	Barabanki	2007
NDF-48	Allahabad	2008
NDF-49	Gonda	2007
NDF-50	Jaunpur	2007
NDF-51	Jaunpur	2007
NDF-52	Gorakhpur	2008
NDF-53	Gorakhpur	2008
NDF-54	Devaria	2008
NDF-55	Deveria	2008
NDF-56	Deveria	2008
NDF-57	Agra	2008
NDF-58	Kanpur	2008
NDF-59	Unnao	2008
NDF-60	Unnao	2008

recorded on five selected plants for nine traits *viz*., plant height, number of branches plant^{-1}, days taken to 50% flowering, number of umbels plant^{-1}, number of umblletes umbel^{-1}, weight of grains umbel^{-1}, days to maturity, test weight and seed yield plant^{-1}. The mean data were statistically analysed for analysis of variance (Panse & Sukhatme 1978). The PCV and GCV (Burton 1952), heritability (broad sense) and genetic advance were computed. The phenotypic and genotypic correlation coefficients were calculated as per methods given by Al-Jibouri *et al.* (1958). The path coefficients were obtained by following the methods of Dewey & Lu (1959).

The analysis of variance for all the traits showed highly significant difference among the genotypes, indicating sufficient amount of variability in the material (Table 2). A wide range of variability for different characters was also observed by Agnihotri (1990), Madhu (1995), Agnihotri *et al.* (1997) and Rajput *et al.* (2004) in fennel.

The highest GCV and PCV were observed for seed yield plant^{-1} followed by weight of grain umbel^{-1}, number of umbels plant^{-1}, number of branches plant^{-1} and number of umbelletes umbel^{-1}. High GCV and PCV for umbels plant^{-1} and seed yield plant^{-1} were also reported by Rajput *et al.* (2004) in fennel. The results suggested that the characters showing high value of GCV and PCV can be easily improved by careful selection.

Table 2. Analysis of variance of various characters in fennel

Characters	Replication MS (2df)	Treatment MS (24 df)	Error MS (48 df)	SEm	CD (P<0.05)	CV %
Plant height (cm)	74.50	1194.45**	38.81	3.59	10.28	5.05
Days to 50% flowering	0.28	30.97**	5.33	1.33	3.81	2.48
Number of branches plant^{-1}	0.45	10.11**	0.93	0.55	1.59	12.17
Number of umbels plant^{-1}	50.56	1143.13**	26.17	2.95	8.44	7.82
Number of umbelletes umbel^{-1}	0.48	33.73**	1.74	0.76	2.17	6.84
Weight of grain umbel^{-1} (g)	0.004	0.194	0.003	0.03	0.09	6.93
Test weight (g)	0.01	1.34*	0.01	0.06	0.17	2.10
Days to maturity	3.45	30.60**	2.45	0.90	3.31	0.69
Seed yield plant^{-1}	147.7**	1121.92**	19.35	2.54	7.26	9.02

*,** significant at P<0.05 and 0.01, respectively

High heritability (broad sense) estimates were found for test weight followed by weight of grain umbel^{-1}, seed yield plant^{-1}, number of umbels plant^{-1}, plant height, number of umbelletes umbel^{-1}, days to maturity, number of branches plant^{-1} and days to 50% flowering indicating that these characters were less influenced by the environment and direct selection for these traits would be effective for further improvement (Table 3). These findings are in agreement with the high heritability estimates in fennel for number of seeds, umbelletes umbel^{-1}, number of umbels plant^{-1}, plant height, number of umbelletes umbel^{-1}, 1000-seed weight and seed yield plant^{-1} reported by Mehta & Patel (1983), Jindal & Allah-Rang (1986), Agnihotri *et al.* (1997) and Rajput *et al.* (2004). High heritability estimates coupled with high genetic advance in per cent of mean were recorded for seed yield plant^{-1}, weight of grains umbel^{-1}, number of umbels plant^{-1}, number of branches plant^{-1}, number of umbelletes plant^{-1}, plant height and test weight indicating the predominance of additive gene action for these characters.

Johnson *et al.* (1955) suggested that heritability together with genetic advance is a more useful parameter in choice of the best genotype by selection. Mehta & Patel (1983) reported high heritability with moderate to high genetic advance for majority of characters except test weight. Jindal & Allah-Rang (1986) estimated high heritability with high genetic advance for number of umbellate umbel^{-1}. Agnihotri *et al.* (1997) founded high heritability with high genetic advance for umbels plant^{-1} and seed yield plant^{-1}, while Rajput *et al*. (2004) estimated high heritability with high genetic advance for number of umbels plant^{-1} and seed yield plant^{-1} in fennel.

The phenotypic and genotypic correlation among the yield and yield components in fennel are presented in Table 4. Significant correlation of characters suggested that there is much scope for direct and indirect selection for further improvement. In general, the estimate of genotypic correlation coefficient was higher than their corresponding phenotypic ones, suggesting strong inherent association among the characters studied. In the present investigation, seed yield was positively correlated with number of umbellets umbel^{-1} and number of branches plant^{-1} (at both the level) and plant height and number of umbels plant^{-1} (at genotypic level). Therefore, these characters should be considered while making selection for yield improvement in fennel. These results are in accordance with the results of Garg *et al.* (2003) for plant height and number of branches plant^{-1} and Singh & Mittal (2002) for plant height and seeds umbel^{-1}.

Positive and significant correlation with seed yield plant^{-1} was found with plant height, days to 50% flowering, number of branches plant^{-1}, number of umbels plant^{-1} and number of umbellets plant^{-1} and number of branches plant^{-1} and thus, these characters are considered as

Table 3. Estimates of mean range, genotypic (GCV) and phenotypic (PCV) coefficient of variation, heritability (h^2) and genetic advance for various characters in fennel

Characters	Mean	Range	GCV %	PCV %	h^2	GA as % of mean
Plant height (cm)	123.17	86.67-151.34	15.93	16.71	90.94	31.28
Days to 50% flowering	93.00	87.00-100.33	3.14	4.00	61.56	5.08
Number of branches plant^{-1}	7.94	4.64-10.80	22.02	25.16	76.60	39.71
Number of umbels plant^{-1}	65.37	26.79-99.93	29.51	30.53	93.43	58.77
Number of umbelletes umbel^{-1}	19.29	12.98-26.33	16.92	18.26	85.93	32.32
Weight of grain umbel^{-1} (g)	0.82	0.50-1.57	30.79	31.57	95.1	61.89
Test weight (g)	5.15	3.98-6.70	12.96	13.13	97.4	26.36
Days to maturity	224.00	218.00-231.33	1.36	1.53	79.27	2.51
Seed yield plant^{-1}	48.74	18.20-98.30	39.33	40.35	95.00	78.97

Table 4. The genotypic and phenotypic (in parenthesis) correlation coefficient among nine quantitative traits in fennel

Character		Plant height (cm)	Days to 50% flowering	Number of branches plant^{-1}	Number of umbels plant^{-1}	Number of umbellets umbel^{-1}	Weight of grains umbel^{-1} (g)	Test weight (g)	Days to maturity	Yield plant^{-1} (g)
		1	2	3	4	5	6	7	8	9
Plant height (cm)	rg	1.00	0.800**	0.929**	0.668**	0.731**	0.202	-0.554**	0.790**	0.779**
	rp	1.00	0.631**	0.815**	0.633**	0.674**	0.193	-0.516**	0.637**	0.738**
Days to 50% flowering	rg		1.00	0.800**	0.813**	0.566**	0.601**	-0.181	-0.573*	0.988**
	rp		1.00	0.631**	0.563**	0.452*	0.451*	-0.129	-0.426*	0.833**
Number of branches plant^{-1}	rg			1.00	0.709**	0.826**	0.097	-0.587*	0.816**	0.801**
	rp			1.00	0.637**	0.696**	0.083	-0.499*	0.548**	0.720**
Number of umbels plant^{-1}	rg				1.00	0.455*	-0.138	-0.297	0.557**	0.869**
	rp				1.00	0.436*	-0.123	-0.287	0.459*	0.833**
Number of umbellets umbel^{-1}	rg					1.00	0.274	-0.541**	0.600**	0.662**
	rp					1.00	0.258	-0.499**	0.444*	0.625**
Weight of grains umbel^{-1} (g)	rg						1.00	-0.102	-0.174	0.145
	rp						1.00	-0.100	-0.136	0.133
Test weight (g)	rg							1.00	-0.553*	-0.332
	rp							1.00	-0.450*	-0.324
Days to maturity	rg								1.00	0.534**
	rp								1.00	0.442*
Yield plant^{-1} (g)	rg									1.00
	rp									1.00

main components for seed yield plant^{-1}. These results are in agreement with the findings of Jindal & Allah-Rang (1986).

The results of the present investigation on path coefficient analysis as presented in Table 5 revealed that days to maturity, days to 50% flowering, number of umbels plant^{-1}, number of umbellets umbel^{-1} and weight of grains umbel^{-1} had maximum positive direct effect on seed yield. These findings are in agreement with Agnihotri *et al.* (1997) for seed yield plant^{-1} and umbels plant^{-1}. Days to 50% flowering had highest positive correlation with seed yield via indirect effect of number of umbels plant^{-1}. Similarly, days to maturity, which had higher positive correlation with seed yield also had next highest positive direct path. The value of residual effect (0.4318) indicated that there may be some other secondary components that should not be ignored.

In the light of the above findings, it may be concluded that improvement in the characters like plant height, number of umbels plant^{-1}, number of umbellets umbel^{-1}, days to 50% flowering and weight of grains umbel^{-1} will help in improving the seed yield in fennel both directly and indirectly. Therefore, these characters should be considered for yield improvement in fennel breeding programme.

Table 5. Direct and indirect effects of different characters on seed yield per plant in fennel

Character	Plant height (cm)	Days to 50% flowering	Number of branches plant^{-1}	Number of umbels plant^{-1}	Number of umbellets umbel^{-1}	Weight of grains umbel^{-1} (g)	Test weight (g)	Days to maturity	Phenotypic correlation with seed yield plant^{-1}
	1	2	3	4	5	6	7	8	9
Plant height (cm)	**-0.425**	0.305	-0.211	0.205	0.149	0.029	0.014	0.405	0.675
Days to 50% flowering	-0.268	**0.483**	-0.164	0.182	0.100	0.067	0.003	-0.271	0.380
Number of branches plant^{-1}	-0.346	0.305	**-0.259**	0.206	0.153	0.012	0.013	0.348	0.638
Number of umbels plant^{-1}	-0.269	0.272	-0.165	**0.324**	0.096	-0.018	0.007	0.292	0.775
Number of umbellets umbel^{-1}	-0.286	0.218	-0.180	0.141	**0.221**	0.038	0.013	0.282	0.619
Weight of grains umbel^{-1} (g)	-0.082	0.217	-0.021	-0.040	0.057	**0.150**	0.002	-0.087	0.283
Test weight (g)	0.219	-0.062	0.129	-0.093	-0.110	-0.015	**-0.027**	-0.286	-0.358
Days to maturity	-0.271	-0.206	-0.142	0.149	0.098	-0.020	0.012	**0.635**	0.363

*Residual effect=0.4318; *Figures in bold indicate direct effect

Acknowledgment

The authors are thankful to the In-charge Coordinating Centre, AICRP on spices, Department of Vegetable Science, N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) for providing seed material and facilities for conducting research.

References

Agnihotri P 1990 Genetic divergence in germplasm of fennel (*Foeniculum valgare* Miller). M.Sc. (Agri.) Thesis, Rajasthan, Agricultural University, Jobner.

Agnihotri P, Dashora S L & Sharma R K 1997 Variability correlation and path analysis in Fennel (*Foeniculum vulgare* Mill). J. Spices Arom. Crops 6: 51–54.

Al-Jibouri N A, Miller P A & Robinson H R 1958 Genotypic and environmental vari-

ances and co-variance in an upland cotton cross of inter-specific origin. Agron. J. 50: 633–636.

Burton G W 1952 Quantitative inheritance in grasses, Proc. 6th Int. Grassland Congress, 1: 227–283.

Dewey D R & Lu K H 1959 A correlation and path analysis of components of crested wheat grass seed production. Agron. J. 51: 515–518.

Garg V K, Shukla, Sudhir & Singh P K 2003 Genetic Association in fennel grown on sodic soil. J. Spices Arom. Crops 12: 171–173.

Jindal L N & Allah-Rang 1986 Variability and association analysis in fennel. Res. Dev. Rep. 3: 50–54.

Johnson H W, Robinson H F & Comstock R E 1955 Estimates of genetic and environmental variability in soyabean. Agron. J. 47: 314–318.

Madhu P 1995 Genetic variability, correlation and path coefficient analysis in fennel. M.Sc. (Ag.). Thesis Gujarat Agricultural University, Sardarkrushinagar.

Mehta K G & Patel R H 1983 Variability in fennel (*Foeniculum vulgare* Mill.) under North Gujarat condition. J. Plantn. Crops 11: 21–23.

Mehta D K, Punjari M M, Saha B C, Brahmachari V S, Jain B P & Maurya K R 1993 Correlation and path analysis in fennel (*Foeniculum vulgare* Mill.). Res. Dev. Rep. 7: 145–149.

Panes V G & Sukhatme P V 1978 Statistical Method for Agricultural Workers. Indian Council of Agricultural Research, New Delhi.

Rajput S S, Singhania D L, Singh D, Sharma K C & Rathore V S 2004 Assessment of genetic variability in fennel (*Foeniculum vulgare* Mill.) germplasm. In: National Seminar on New Perspectives in Commercial Cultivation, Processing and Marketing Seed Spices and Medicinal Plants (pp.11): 25–26 March 2004, Jobner.

Singh Y & Mittal P 2002 Studies on variability, heritability and scope of improvement in fennel (*Foeniculum vulgare* Mill.). Bioved. 13: 7–9.