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Variability, character association and path coefficient analysis in fennel

Abhay Dashora* and E.V.D. Sastry

Department of Plant Breeding and Genetics, S.K.N. College of Agriculture, Jobner 303 329, Rajasthan

ABSTRACT

Genetic variability, heritability, correlation and path analysis were estimated among 45 genotypes of 10 quantitative characters in fennel. The highest genotypic and phenotypic coefficient of variation was observed for seed yield per plant and biological yield per plant. High heritability coupled with high genetic advance as per cent of mean was observed for seeds per umbel and biological yield per plant indicating the importance of additive gene effects for these traits. The umbellets per umbel (0.43), seeds per umbel (0.46**), biological yield per plant (0.84**) and harvest index (0.45**) exhibited positive and significant correlation with the seed yield. Path coefficient analysis revealed that seeds per umbel had highest direct effect on seed yield followed by test weight and biological yield per plant. Therefore, greater emphasis should be given on these characters while selecting for higher yield and related traits.**

Key words: Fennel, variability, character association, path coefficient analysis.

INTRODUCTION

Fennel (*Foeniculum vulgare* Mill., 2n = 22), an important seed spice crop, mainly cultivated for its seeds in the state of Rajasthan and Gujarat. The crop has potential as cash crop in the state of Rajasthan. To make this crop more productive and resistant to diseases and insect-pests, breeders have to launch an intensive breeding programme for releasing array of variability. Development of high yielding cultivars requires knowledge of the existing genetic variation and also the extent of association among yield contributing characters. The observed variability is a combined estimate of genetic and environmental causes of which only the former one is heritable. However, the estimate of heritability alone does not provide an idea of the expected gain in the next generation but it has to be considered in conjunction with genetic advance. Correlation and path analysis will establish the extent of association between yield and its component and also bring out the relative importance of their direct and indirect effects and thus, give a clear understanding of their association with yield.

Keeping this in view, the present investigation was made to explore the genetics variability, by determining the magnitude of genetic coefficient of variation, heritability estimates and expected genetic advance of different biometric traits, their correlation and effects in 45 fennel genotypes.

*Department of Plant Breeding and Genetics, Rajasthan College of Agriculture, MPUAT, Udaipur 313 001; E-mail : abhayd1971@gmail.com

MATERIALS AND METHODS

Forty-five genotypes including 9 parents and 36 F_1s of fennel were evaluated in Randomized Complete Block Design with three replications at the Research Farm, SKN College of Agriculture, Jobner. In each replication, genotypes were sown in a plot of 2.0 m x 0.9 m size accommodating two rows of 2.0 m length spaced 45 cm apart with an intra-row spacing of 20 cm maintained by dibbling. All the recommended package of practices was followed to raise a good crop. Ten competitive plants were marked in each plot per replication and observations were recorded on these plants. Observations were recorded on these plants for height up to main umbel (cm), height up to the tip of tallest umbel which hereafter referred as plant height (cm), umbels per plant, umbellets per umbel, seeds per umbel, biological yield per plant (g), harvest index (%) and seed yield per plant (g), while for days to 50% flowering and test weight (g), the data were recorded on whole plot basis.

Analysis of variance was done by the method suggested by Panse and Sukhatme (7). The phenotypic and genotypic coefficient of variation (Burton, 3), 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.* (2). The path coefficients were obtained by following the method of Dewey and Lu (4).

RESULTS AND DISCUSSION

Analysis of variance revealed significant differences among genotypes for all the traits studied indicating presence of significant variability in the materials

Table 1. Analysis of variance (ANOVA) for different characters in fennel.

Character	Replication (2)	Genotype (44)	Error (88)
Days to 50% flowering	1.70	18.76**	4.23
Height up to main umbel	407.25	220.46**	137.66
Plant height	247.52	194.63**	103.49
Umbels per plant	37.90	76.61**	16.15
Umbellets per umbel	5.33	39.74**	7.31
Seeds per umbel	6692.30	16337.30**	3653.04
Biological yield per plant	9.12	684.31**	95.52
Seed yield per plant	14.90	67.74**	6.21
Test weight	0.02	1.69**	0.39
Harvest index	38.87	34.79**	12.81

Figures in parenthesis are degree of freedom; *,**Significant at 5 and 1% levels.

Table 2. Range, mean, phenotypic and genotypic coefficient of variation, heritability and genetic advance as per cent of mean of various characters in fennel.

Character	Range	Mean ± SE	Phenotypic coefficient of variation (PCV)	Genotypic coefficient of variation (GCV)	Heritability (Broad sense) (%)	Genetic advance as % of mean
Days to 50% flowering	114.33-126.67	121.47 ± 1.68	2.48	1.81	53.36	2.73
Height up to main umbel (cm)	91.07-128.80	106.64 ± 9.58	12.05	4.93	16.70	4.15
Plant height (cm)	115.47-158.00	139.89 ± 8.31	8.27	3.94	22.69	3.87
Umbels per plant	20.33-42.47	27.95 ± 3.28	21.56	16.06	55.50	24.64
Umbellets per umbel	19.67-33.87	25.54 ± 2.21	16.64	12.85	59.67	20.45
Seeds per umbel	208.07-553.30	374.44 ± 49.35	25.55	18.71	53.65	28.24
Biological yield per plant (g)	36.97-102.93	57.25 ± 7.98	29.84	24.47	67.26	41.34
Seed yield per plant (g)	9.26-31.56	15.44 ± 2.03	33.47	29.33	76.76	52.93
Test weight (g)	5.47-8.77	6.80 ± 0.51	13.38	9.64	51.99	14.33
Harvest index (%)	21.67-36.84	27.06 ± 2.92	16.58	10.00	36.38	12.43

(Table 1). The range of variation was high for seeds per umbel (208.07-553-30) followed by biological yield per plant (36.97-102.93 g) and plant height (115.47-158.00 cm) (Table 2). A better idea can be gained by comparing the relative amount of coefficient of phenotypic and genotypic variance for the actual strength of variability. The estimates of phenotypic coefficient of variation (PCV) were higher than genotypic coefficient of variation (GCV) for all the traits studied which is an indicator of additive effect of the environment on the expression of the trait. The estimates of PCV and GCV indicated the existence of fairly high degree of variability for seed yield per plant and biological yield per plant. High magnitude of PCV and GCV was also observed for seed yield per plant by Singh and Mittal (10). Moderate variability was observed for seeds per umbel, umbels per plant, umbelletes per umbel, harvest index and test weight while the estimates of PCV and GCV have been found relatively low for height up to main umbel, plant height and days to 50% flowering. The seed yield per plant showed the highest PCV value of 33.47% in comparison to GCV of 29.33% suggesting less environmental influence on this character, which was confirmed by its high heritability. The difference between PCV and GCV was minimum for days to

Table 3. The genotypic and phenotypic (in parenthesis) correlation coefficient among 10 quantitative traits in fennel.

Character		Days to 50% flowering	Height up to main umbel	Plant height	Umbels per plant	Umbellets per umbel	Seeds per umbel	Biological yield per plant	Test weight	Harvest index	Seed yield per plant
Days to 50% flowering	rg	**1.00**	0.14	0.13	0.08	0.19	-0.01	0.21	-0.03	-0.28	0.09
	rp	**(1.00)**	(-0.01)	(0.06)	(0.12)	(0.09)	(0.14)	(-0.07)	(-0.13)	(0.07)	(0.08)
Height upto main umbel	rg		**1.00**	1.70	-0.16	0.90**	1.08	0.12	-0.61**	0.05	0.15
	rp		**(1.00)**	(0.47**)	(-0.09)	(0.41**)	(0.32*)	(0.04)	(-0.19)	(-0.01)	(0.05)
Plant height	rg			**1.00**	0.10	0.80**	0.85	0.44**	-0.26	-0.17	0.34*
	rp			**(1.00)**	(-0.09)	(0.37**)	(0.38**)	(0.21)	(-0.06)	(-0.05)	(0.18)
Umbels per plant	rg				1.00	0.17	0.10	0.20	-0.10	0.38*	0.31*
	rp				**(1.00)**	(0.13)	(0.08)	(0.14)	(-0.08)	(0.19)	(0.23)
Umbellets per umbel	rg					1.00	0.92**	0.57**	-0.24	0.10	0.55**
	rp					**(1.00)**	(0.62**)	(0.39**)	(-0.12)	(0.13)	(0.43**)
Seeds per umbel	rg						**1.00**	0.56**	0.01	0.24	0.56**
	rp						**(1.00)**	(0.42**)	(0.08)	(0.16)	(0.46**)
Biological yield per plant	rg							**1.00**	0.31*	0.23	0.92**
	rp							**(1.00)**	(0.29)	(-0.07)	(0.84**)
Test weight	rg								**1.00**	0.19	0.33*
	rp								**(1.00)**	(0.06)	(0.28)
Harvest index	rg									**1.00**	0.58**
	rp									**(1.00)**	(0.45**)
Seed yield per plant	rg										**1.00**
	rp										(1.00)

*, **Significant at 5 and 1% levels, rg = genotypic correlation; rp = phenotypic correlation

Table 4. Direct and indirect effect of different characters on seed yield in fennel.

Character	Days to 50% flowering	Height upto main umbel	Plant height	Umbels per plant	Umbellets per umbel	Seeds per umbel	Biological yield per plant	Test weight	Harvest index	Correlation coefficient with seed yield
Days to 50% flowering	**0.798**	-0.047	-0.248	0.030	-0.944	-0.068	0.328	0.081	0.188	0.085
Height upto main umbel	0.109	**-0.349**	-3.184	-0.060	-4.469	6.833	0.184	1.118	-0.033	0.149
Plant height	0.105	-0.593	**-1.876**	0.037	-3.980	5.355	0.704	0.466	0.115	0.336*
Umbels per plant	0.067	0.057	-0.194	**0.366**	-0.840	0.616	0.311	0.181	-0.253	0.312*
Umbellets per umbel	0.151	-0.314	-1.501	0.061	**-4.973**	5.849	0.906	0.436	-0.066	0.551**
Seeds per umbel	-0.008	-0.376	-1.584	0.035	-4.587	**6.342**	0.884	0.012	-0.160	0.557**
Biological yield per plant	0.165	-0.040	-0.832	0.017	-2.842	3.535	**1.586**	-0.566	-0.157	0.919**
Test weight	-0.021	0.214	0.480	-0.036	1.191	-0.041	0.493	**1.822**	-0.131	0.326*
Harvest index	-0.222	-0.017	0.321	0.137	-0.491	1.512	0.371	-0.355	**-0.674**	0.582**

Residual effect = 0.49; Bold figures in main diagonal indicate direct effects.

50% flowering, test weight, umbellets per umbel and seed yield per plant suggesting that these traits were least affected by environment. This observation draws support from the high value of heritability recorded for these traits.

With the help of PCV and GCV alone, it is not possible to determine the amount of variation which is heritable. The heritability along with genetic advance is more meaningful and help in predicting the resultant effect of selection on phenotypic expression. Estimates of heritability in broad sense was high for seed yield and biological yield; low for height up to main umbel**,** plant height and harvest index whereas the estimates of heritability for umbellate per umbel, umbels per plant, seeds per umbel, days to 50% flowering and test weight were moderate. In corollary to high heritability estimates, high estimates of genetic advance as per cent of mean was also observed for seed yield and biological yield per plant indicating predominance of additive gene effects for these traits. This is in accordance with the findings reported by Agnihotri *et al*. (1), and Singh and Mittal (10) for seed yield per plant, and Shukla *et al*. (8) for biological yield per plant.

Yield of a crop is the result of interaction of a number of inter-related characters. Therefore, selection should be based on these component characters after assessing their correlation with yield. Character association revealed the mutual relationship between two characters, and it is important parameters for taking a decision regarding the nature of selection to be followed for improvement in the crop under study. The phenotypic and genotypic correlation among the yield and yield components in fennel are presented in Table 3. 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, thereby, suggesting strong inherent association among the characters studied. In the present investigation, seeds yield was positively correlated with umbelletes per umbel, seeds per umbel, biological yield and harvest index (at both the level) and plant height, umbels per plant and test weight (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*. (5) for plant height and biological yield per plant, and Singh and Mittal (10) for plant height and seeds per umbel.

Harvest Index showed positive and significant genotypic correlation with umbels per plant. On the other hand biological yield showed positive and significant correlation with plant height, umbelllets per umbel and seeds per umbel. Similar results have also been reported by Singh and Sastry (9) for umbelllets per umbel and seeds per umbel. The trait, umbelllets per umbel showed positive and significant correlation with height up to main umbel and plant height. Seeds per umbel showed positive and significant correlation with umbelllets per umbel. The observations are in agreement with the findings of Jindla and Allah (6).

Yield is the sum total of the several component characters which directly or indirectly contributed to it. The information derived from the correlation studies indicated only mutual association among the characters. Whereas, path coefficient analysis helps in understanding the magnitude of direct and indirect contribution of each character on the dependent characters like seed yield. Partitioning of correlation coefficient into direct and indirect effects provide information about the nature and magnitude of effects of other characters on seed yield.

The results of the present investigation on path coefficient analysis as presented in Table 4 revealed that seeds per umbel, test weight and biological yield per plant had maximum positive direct effect on seed yield. These findings are in agreement with Agnihotri *et al*. (1) for seed yield per plant. Biological yield per plant had highest positive correlation with seed yield via indirect effect of seeds per umbel. Similarly test weight, which had higher positive correlation with seed yield, also had next highest positive direct path. It was also indirectly and positive *via* height up to main umbel, plant height, umbellets per umbel and biological yield. The value of residual effect (0.49) indicates that there may be some other secondary components that should not be ignored.

In the light of above findings, it may be concluded that improvement in the characters like seeds per umbel, biological yield per plant, days to 50% flowering and umbels per plant 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.

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