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Genetic Variability Studies in Fennel (*Foeniculum vulgare*) in Arid Western Rajasthan

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Abstract: Eighteen genotypes of fennel were evaluated to assess the extent of genetic variability, heritability, and genetic advance. Analysis of variance showed significant differences among the genotypes and significant variability concerning all the characters. Phenotypic variances estimates were higher than genotypic variances for all the characters, but the difference was low, depicting lower influence of environment on the expression of the traits. In addition, high heritability (broad sense) coupled with high genetic advance as a percent of mean was observed in fennel genotypes for dry matter accumulation at maturity, biological yield, harvest index (%), and oil content. The genotype RF-205 performed prominent for seed yield and essential oil content which is the important economical trait, this genotype is an important genetic resource for fennel genetic improvement for arid environment.

Key words: Fennel, genotypes, genetic variability, heritability, genetic advance

Fennel (*Foeniculum vulgare* Mill.) is a cross-pollinated diploid species with chromosome number $2n=22$ belonging to the family Apiaceae. It is native to Europe and the Mediterranean region (Agrawal *et al.*, 2001). Fennel is cultivated throughout the temperate and subtropical regions in the world. In India, it is mainly grown in Gujarat and Rajasthan as a cold-weather crop. In Rajasthan, fennel is mainly cultivated in the Southwestern regions. Among all the seed spices, fennel has potential as a cash crop in the state of Rajasthan (Mahla and Ramakrishna, 2002).

The development of high-yielding varieties requires knowledge of the existing genetic variability and heritability of characters. Therefore, evaluating the available germplasm is important for gathering information about genetic variability in a particular crop. However, since most yield attributing characters are quantitatively inherited and highly affected by the environment, it is difficult to judge whether the observed variability is heritable. Therefore, besides genetic variability, the estimates of the genotypic and phenotypic coefficient of variations (GCV and PCV, respectively), genetic advance, and heritability are helpful in understanding the nature of inheritance of different traits. Therefore, the present study was undertaken to estimate the genetic variability,

heritability, and genetic advance in fennel in arid western Rajasthan.

Materials and Methods

A total of 18 fennel genotypes were grown in randomized complete block design with three replications during rabi 2016-17 at College of Agriculture, Mandor, Jodhpur (Rajasthan). Each genotype was planted in an experimental plot size of 12 m^2 ($4\text{ m} \times 3\text{ m}$) with $45\text{ cm} \times 30\text{ cm}$ of row to plant spacing. The recommended package of practices was adopted to raise a healthy crop. The crop was irrigated at regular intervals to maintain optimum moisture throughout the experimentation. For observations, 10 competitive plants were marked in each plot. Observations were recorded on 13 different growths and yield parameters and for quality analysis essential oil content present in the seed was estimated. Thirty grams of cleaned fennel seeds from each entry was used for essential oil extraction by hydro-distillation using a Clevenger apparatus (Clevenger, 1928) for 3 h. After decanting and drying of the oil over anhydrous sodium sulphate the corresponding mild yellowish colored oil were recovered and calculated in terms of percentage (V/W).

The data obtained on various characters were subjected to statistical analysis as per randomized block design. The mean data were statistically analyzed for analysis of variance (Panse and Sukhatme, 1978). To compare the

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Table 1. Mean performance of fennel genotypes for growth, yield and essential oil content

Genotypes	Plant height at maturity (cm)	Dry matter accumulation (g plant ⁻¹)	No. of effective branches plant ⁻¹	Days to 50% flowering	Days to maturity	No. of umbels plant ⁻¹	No. of umbellets umbel ⁻¹	No. of seeds umbel ⁻¹	1000-seed weight (g)	Seed yield (g plant ⁻¹)	Seed yield (t ha ⁻¹)	Biological yield (t ha ⁻¹)	Harvest index (%)	Essential oil content (%)
RF-101	149	60.5	20.0	96.3	168	21.4	21.9	265	4.27	24.2	1.61	5.52	29.3	1.13
RF-125	135	59.5	24.7	103.3	171	23.1	19.4	298	4.20	28.0	1.90	5.86	32.8	1.15
RF-143	163	105.2	29.3	103.3	175	23.6	21.4	249	4.46	25.8	1.76	8.73	20.1	1.47
RF-145	162	101.5	28.3	99.7	171	22.4	23.9	300	4.30	28.9	1.97	8.68	22.7	1.39
RF-157	160	99.5	27.3	98.7	171	25.1	20.9	294	4.50	33.1	2.22	8.83	25.2	1.92
RF-178	157	97.3	26.7	103.7	172	24.2	24.0	275	4.21	27.9	1.83	8.03	22.9	1.22
RF-205	151	95.8	26.0	99.3	170	24.0	23.0	309	5.10	37.7	2.52	8.56	29.5	2.35
AF-01	169	93.2	25.9	103.3	173	22.1	25.4	270	5.03	29.8	2.01	8.20	24.6	1.56
AF-02	155	83.5	24.1	103.0	170	21.9	24.8	255	4.60	25.8	1.77	7.28	24.4	2.16
GF-02	144	54.7	20.7	99.3	170	19.4	23.0	297	5.13	29.5	1.95	5.58	35.1	1.63
GF-11	145	55.3	20.2	99.0	167	19.3	23.3	325	5.23	31.3	2.09	5.79	36.1	1.47
GF-12	135	50.7	24.3	100.0	170	23.0	24.8	262	5.32	31.5	2.06	5.43	38.1	1.32
Hisar Swaroop	171	101.2	19.1	109.3	178	18.8	22.5	268	4.94	24.5	1.62	8.36	19.5	1.52
Pant Madhurika	170	97.7	21.2	104.7	176	19.0	23.5	269	4.69	23.8	1.58	8.16	19.8	0.94
Azad Saunf-1	157	85.8	22.3	99.3	169	22.0	21.6	301	4.85	30.9	2.04	7.76	26.4	1.13
Co-01	148	58.2	21.4	95.3	163	19.6	24.0	276	5.03	26.5	1.80	5.61	32.2	2.15
Rajendra Saurabh	161	80.2	22.0	104.7	177	21.3	26.2	282	5.21	31.3	2.06	7.43	27.9	1.52
Sirohi Selection	143	55.2	21.4	102.3	172	20.9	23.9	253	5.21	27.2	1.75	5.50	31.8	1.27
SEm±	5.1	2.4	1.0	2.2	2.2	0.9	1.0	8.1	0.12	1.1	0.067	0.336	1.6	0.04
CD (P=0.05)	15	6.8	2.7	6.5	6	2.6	2.8	23	0.33	3.1	0.19	0.97	4.5	0.13

Table 2. Mean, range, coefficients of variation, heritability, expected genetic advance and genetic advance as per cent of mean for various characters of fennel genotypes

Characters	Mean	Range		Coefficients of variation (%)		Heritability (h ²) (%)	Expected genetic advance	Genetic advance (mean %)
		Min.	Max.	Genotypic	Phenotypic			
Plant height at maturity (cm)	154.00	135.00	171.00	6.39	8.61	55.13	15.09	9.77
Dry matter accumulation (g plant ⁻¹)	79.70	50.1	105.20	25.30	25.82	96.06	40.73	51.09
No. of effective branches plant ⁻¹	23.60	19.1	29.30	12.56	14.38	76.24	5.33	22.58
Days to 50% flowering	101.40	96.3	109.30	2.19	3.83	24.70	2.28	2.24
Days to maturity	171.00	163	178.00	1.62	2.74	34.99	3.38	1.97
No. of umbels plant ⁻¹	21.70	18.77	25.13	7.79	10.66	53.43	2.55	11.73
No. of umbellets umbel ⁻¹	23.20	19.43	26.19	6.06	9.38	41.81	1.87	8.07
No. of seeds umbel ⁻¹	280.40	248	325.00	7.10	8.68	66.80	33.50	11.95
1000-seed weight (g)	4.79	4.20	5.32	7.84	8.87	78.16	0.68	14.28
Seed yield (g plant ⁻¹)	28.70	23.80	37.73	11.82	13.52	76.44	6.12	21.28
Seed yield (t ha ⁻¹)	1.92	1.58	2.52	11.75	13.21	79.13	413.00	21.54
Biological yield (t ha ⁻¹)	7.18	5.43	8.83	18.27	19.98	83.59	2472.00	34.42
Harvest index (%)	27.69	19.50	38.07	20.04	22.27	81.01	10.29	37.17
Essential Oil content (%)	1.52	0.94	2.35	25.91	26.43	96.10	0.78	52.33

genotypes, GCV, PCV, heritability (h²), and genetic advance (GA) were calculated for each character by using standard statistical procedures (Burton and De Vane, 1953).

Results and Discussion

The results revealed that the fennel genotypes differed significantly for all the parameters studied (Table 1). This indicates the presence of an adequate amount of variability, that can be helpful in the selection of suitable genotypes. The highest plant height at maturity was recorded in ‘Hisar Swaroop’ followed by ‘Pant Madhurika’ and ‘AF-01’ while; was lowest in ‘GF-12’. The variation in plant height was due to the inherent genetic makeup of the genotypes, which in some way may be influenced by the activity of endogenous growth regulators. These results are in agreement with Rawat *et al.* (2013), Sengupta *et al.* (2014), Jeeterwal *et al.* (2015), and Kumar *et al.* (2017). The highest values of dry matter accumulation and number of effective branches per plant were recorded in ‘RF-143’ followed by ‘RF-145’. A probable reason for higher dry matter accumulation was the higher number of branches per plant and comparatively longer crop duration, which resulted in accumulation of more photosynthates. These results agree

with the findings of Shaktawat *et al.* (2016) and Sengupta *et al.* (2014).

Genotype ‘Co-1’ was found earliest in commencement of 50% flowering and maturity, while ‘Hisar Swaroop’ was observed to take the longest duration. These results are in lines with the earlier findings of Kumawat (2010) and Dashora and Sastry (2011). The minimum branches per plant in ‘Co-1’ might have resulted in a high quantity of florigen synthesis, responsible early commencement of the reproductive phase. The early genotypes can be especially useful for developing short-duration cultivars to fetch better market price and can give better economic returns. The maximum number of umbels per plant and biological yield was recorded in ‘RF-157’. Genotypes ‘Rajendra Saurabh’ exhibited maximum umbellets per umbel, while the lowest umbellets per umbel were noted in ‘RF-125’. Similar results were also reported by Kumawat (2010). The maximum number of seeds per umbel was reported in ‘GF-11’ followed by ‘RF-205’ and ‘Azad Saunf-1’, while minimum in ‘RF-143’. The highest values of harvest index and 1000-seed weight were recorded in ‘GF-12’ followed by ‘GF-11’. These findings confirm well with the results of Yogi *et al.* (2014). The variation observed in these

traits may be due to the genetic makeup of the genotypes. Maximum seed yield was noted in 'RF-205' closely followed by 'RF-157', while 'Pant Madhurika,' 'RF-101' and 'Hisar Swaroop' being at par recorded lowest seed yield. These findings confirm with Kumawat (2010) and Shaktawat *et al.* (2016). Genotype 'RF-205' closely followed by 'AF-02' and 'Co-1' recorded the highest essential oil content, while 'Pant Madhurika,' 'RF-101' and 'Azad Saunf-1' was observed to be lowest in essential oil content. The findings are in close conformity with Yogi *et al.* (2014) and Saxena *et al.* (2016).

The mean performance of the genotypes shows a wide range of variability for all the traits (Table 2). The variation was highest for biological yield (5.43-8.83 t ha⁻¹) followed by seed yield (1.58-2.52 t ha⁻¹) and the number of seeds per umbel (248-325). This may be due to the existence of diversity in genotypes evaluated. The range and coefficient of variations were high for essential oil content, dry matter accumulation at maturity, and harvest index. Similar findings also reported by Jeeterwal *et al.* (2015); Saxena *et al.* (2016); Kumar *et al.* (2017). For all the characters studied, the PCV was higher than the corresponding GCV (Table 2). However, the differences between PCV and GCV were narrow, which implied minimum effect of environmental variations. It also indicates that genetic factors have been predominantly responsible for the expression of specific attributes and selection could be made effectively based on phenotypic performance.

In the present investigation, heritability, was observed to be high for dry matter accumulation at maturity, essential oil content, biological yield, and harvest index (Table 2). This is indicative of the fact that these characters are less influenced by the environment and may respond much to selection. High heritability is helpful in identifying appropriate characters for selection and enables the breeder to select superior genotypes based on phenotypic expression of quantitative characters. Similar findings are reported by Jeeterwal *et al.* (2015); Saxena *et al.* (2016); Kumar *et al.* (2017). Genetic advance as percentage of mean ranged between 2.0% for days to maturity to 52.3% for essential oil content. High magnitude (>40%) of genetic advance (Table 2) was estimated for essential oil content and dry matter accumulation at maturity, which is in agreement with earlier

reports of Jeeterwal *et al.* (2015), Saxena *et al.* (2016), and Kumar *et al.* (2017).

Conclusion

High heritability coupled with high genetic advance for traits like essential oil content, dry matter accumulation at maturity, biological yield, and harvest index suggested the preponderance of additive genes. Results indicate that these parameters are very important for selecting a suitable genotype because if the heritability of a character is high, selection for such a character should be fairly easy. This is because there would be a close correspondence between genotypic and phenotypic variation due to a relatively smaller contribution of the environment to the phenotype. The genotype RF-205 performed prominent for seed yield and essential oil content which is the important economical trait, this genotype is an important genetic resource for fennel genetic improvement for arid environment.

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