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Genetic variability, heritability and genetic advance in some strains of Fennel (*Foeniculum vulgare* Mill.)

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Abstract
The present research work was conducted at Vegetable Research Farm Narendra Deva University of Agriculture and Technology, (Narendra Nagar) Kumarganj, Faizabad (U.P.) India, during 2011 in *rabi* season and evaluated seventy strains. The main focus of this field trail was to estimate the component of variance, phenotypic and genotypic coefficient, heritability and genetic advance over mean for different growth and yield parameters. Knowledge of selection effects on positive or negative changes of a character under improvement is of paramount importance for the success of any plant breeding program and it's generally helps the selection of a desirable improvement breeding method. Heritability and genetic advance are important selection parameter to improvement of crops. The characters Germination (%), Plant height (cm), Days to 50% flowering, Number of branches plant, Number of umbels plant, Number of umbellets umbel, Weight of grains umbel, Test weight (g), Days to maturity, Seed yield/ plant (g) and Seed yield q ha difference between GCV and PCV were recorded for all the characters.

Keywords: Genetic variability, heritability and genetic advance, *Foeniculum vulgare* Mill.

Introduction
Among the spices Fennel (*Foeniculum vulgare* Mill.) Syn. *Foeniculum officinale.* All is one of the most important seasonal spices and medicinal crop of the country. It is erect, stout glabrous and aromatic annual herb (biennial with potency regeneration). Its plant height is 1.5 to 1.8 m. The seed is small, oblong ellipsoidal or cylindrical, 6-7 mm long, straight or slightly curved and of greenish yellow or yellowish brown colour. The mesocarp is 5 ridged and it possesses an agreeable and sweet aroma resembling Aniseed. It is commercial crop, which is grown in tropics and subtropics. The genus foeniculum belongs to the family umbeliferae (Apiaceae) and is cultivated in Mediterranean countries, in Romania and India. Thus, fennel is considered to be the native of South Europe.

The most important fennel growing state in India is Gujarat, Rajasthan and to some extent in Uttar Pradesh, Punjab, Haryana, Bihar, Maharashtra and Karnataka. Fennel is also cultivated as a garden or home yard crop in states like Punjab, Haryana, Bihar, Maharashtra, Karnataka etc. Gujarat is the leading state in fennel production which contributes about 85-90 per cent of total production in India.

It is used in various Indian dishes for flavoring soups, sauces pastries confectioneries, bread rolls, liquors meat dishes and in the seasoning of pickles. In India, fennel seeds are chewed alone or in betel leaf. The fennel leaves are used in fish sauce and for garnishing and the leaf stalks are used as salad. The genetic improvement of any crop depends upon its judicious exploitation through efficient breeding method. The magnitude of genetic variability in the economic characters in modern farming system, few high yielding varieties dominate in cultivation which often lead to genetic homogeneity. It is also well established that genetic homogeneity leads to genetic variability to biotic and a biotic stresses. In any crop breeding programme, germplasm source as the most valuable reservoir in providing variability for various traits. Proper screening and evaluation of germplasm lines would provide an estimate of their potential value as suitable genotypes for utilization in varietal development programme.

Genetic variability forms the basis for crop improvement. The success of any breeding programme depends upon the nature and magnitude of genetic variability available in the

breeding material. Selection and hybridization approaches are easily followed in bringing about the quantitative improvement in order to bring about desired improvement. It is essential to assess nature and magnitude of variability, heritability and genetic advance for various characters in respect of germplasm available for maximizing the correlated response to selection.

Material and Methods

The present investigation was conducted at Vegetable Research Farm Narendra Deva University of Agriculture and Technology, (Narendra Nagar) Kumarganj, Faizabad (U.P.) India, during 2011 in *rabi* season. The experimental materials comprised of 70 seventeen genotypes including 3 check of Fennel *viz.*, NDF-1, NDF-2, NDF-3, NDF-4, NDF-5, NDF-6, NDF-7, NDF-8 NDF-9 NDF-10 NDF-11 NDF-12 NDF-13, NDF-14, NDF-15, NDF-16,NDF-17, NDF-18, NDF-19, NDF-20, NDF-21, NDF-22, NDF-23, NDF-24, NDF-25, NDF-26, NDF-27, NDF-28, NDF-29, NDF-30, NDF-31, NDF-32, NDF-33, NDF-34, NDF-35, NDF-36, NDF-37, NDF-38, NDF-39, NDF-40, NDF-41, NDF-42, NDF-43, NDF-44, NDF-45, NDF-46, NDF-47, NDF-48, NDF-49, NDF-50, NDF-51, NDF-52, NDF-53, NDF-54, NDF-55, NDF-56, NDF-57, NDF-58, NDF-59, NDF-60, NDF-61, NDF-62, NDF-63, NDF-64, NDF-65, NDF-66, NDF-67, NDF-68, NDF-69, NDF-70 and 3check namely (GF-2, NDF-12, RF-101) collected from different parts of Uttar Pradesh. The seeds were sown in the nursery bed and seedlings are ready for transplanting after 6-7 weeks. All the recommended agronomic package of practices was followed. The observation were recorded on ten randomly selected plants per treatment from each replication for 11 quantitative traits, *viz.*, Germination (%), Plant height (cm), Days to 50% flowering, Number of branches plant, Number of umbels plant, Number of umbellets umbel, Weight of grains umbel, Test weight (g), Days to maturity, Seed yield/ plant (g) and Seed yield q ha**.** The statistical analysis was done by using the techniques of analysis of "Augmented Block Design". These designs were developed by Federer (1956) [4]. The genotypic and phenotypic coefficients of variation were calculated using the formulae of Burton and De Vane (1953) [2]. The heritability and genetic advance were calculated according to Allard (1960) [1] and genetic advance as percent of mean was estimated using the method of Johnson *et al.* (1955) [5].

Result and Discussion

Variability plays an important role in crop breeding. An insight in to the magnitude of variability present in crop species is of utmost importance as it provides the basis of selection. The mean sum of squares due to genotypes showed significant differences for all the characters (Table-1). The characters studied in the present investigation exhibited low, moderate and high PCV and GCV values (Table-2).

The phenotypic coefficient of variation was estimated on the basis of seventy genotypes for eleven characters viz., seed yield plant^{-1} (18.05) showed highest PCV followed by number of branches per plant (9.58) test weight (7.41), germination per cent (5.59) and weight of grains per umbel (5.20). Low range of PCV was observed for days to maturity and days to 50% flowering. Rest of character showed moderate PCV. The data on phenotypic coefficient of variation indicated that there would be greater scope of selection for the characters, namely seed yield plant, number of branches plant, test weight, germination per cent and weight of grains umbel whereas, days to 50% flowering, days to maturity may be least effective.

Seed yield plant showed highest genotypic coefficient of variation (14.27) followed by number of branches plant (5.87), germination per cent (4.71) and test weight (4.51). Moderate GCV was noticed in number of umbellets per umbel followed by weight of grain per umbel and seed yield q ha. Plant height (2.32), days to 50% flowering (1.4), number of umbel plant (2.61) and days to maturity (0.63) showed low range of GCV.

The heritability in broad sense was moderate in germination per cent and seed yield plant, whereas number of umbellets plant (48.0%), weight of grain per umbel (43.0%), plant height (40.0%), days to maturity (40.0%), number of branches plant (38.0%), days to 50% flowering (37.0%), test weight (37.0%), seed yield q ha (37.0%) and number of umbel plant (35.0%) exhibited low heritability. Similar result was reported by., Patel and Patel (2015) [8]. Sengupta *et al.* (2014) [9]. Sharma, *et al.* (2015) [10].

The genetic advance in per cent of mean was highest in case of seed yield plant (23.24). However, low genetic advance in per cent of mean observed in germination percentage (8.17), number of branches plant (7.42), test weight (5.65), number of umbellets umbel (4.99), seed yield (q ha) (4.12), number of umbel plant (3.19), plant height (3.02), days to 50% flowering (1.76) and days to maturity (0.82) and weight of grains per umbel (0.06). Similar result was reported by Dashora and Sastry (2011) [3], Federer (1956) [4], Meena *et al.* (2013) [6]. Patel *et al.* (2008) [7].

Heritability estimate provide the assessment of amount of transmissible genetic variability to the total variability and happens to be the most important basic factor that determine the genetic improvement or response to selection. However, the degree of improvement attained through selection not only depends upon heritability but also on the amount genetic variation present in the breeding population and extent of the selection pressure applied by the breeder. The parameters genetic advance in per cent of mean is a more reliable index for understanding the effectiveness of selection in improving the trait because its estimate is derived by involvement of heritability phenotypic standard deviation and intensity of selection. Thus heritability and genetic advance in per cent of mean in combination, provides clearer picture regarding the effectiveness of selection for improving the character. In the present study, the heritability in broad sense was moderate in germination per cent and seed yield plant, whereas number of umbellets plant (48.0%), weight of grain per umbel (43.0%), plant height (40.0%), days to maturity (40.0%), number of branches plant^{-1} (38.0%), days to 50% flowering (37.0%), test weight (37.0%), seed yield q ha (37.0%) and number of umbel plant (35.0%) exhibited low heritability.

Table 1: Analysis of variance of augmented design of checks for eleven characters in fennel genotypes.

S. No.	Source of variance	Source of variation		
	d.f.	Blocks (6)	Checks (2)	Error (12)
1.	Germination (%)	13.15	123.190**	6.802
2.	Plant height (cm)	26.09	102.446**	18.085
3.	Days to 50% flowering	0.69	16.404**	3.227
4.	Number of branches plant^{-1}	0.37	7.023**	1.344
5.	Number of umbels plant^{-1}	10.48	98.332**	20.449
6.	Number of umbellets per umbel	1.42	12.930**	1.760
7.	Weight of grains per umbel (g)	0.00	0.008**	0.001
8.	Test weight (g)	0.17	0.744*	0.146
9.	Days to maturity	2.64	17.719**	3.167
10.	Seed yield plant^{-1} (g)	31.50	214.673**	16.949
11.	Seed yield q ha^{-1}	0.12	1.080**	0.209

Table 2: Range, general mean, genotypic and phenotypic coefficient of variation, heritability (h^2bs) genetic advance and genetic advance in per cent of mean and coefficient of variation

Character	Range		General mean	GCV%	PCV%	h^2bs	GA	GA% Mean
	Min.	Max.						
Germination (%)	59.95	99.71	91.43	4.71	5.59	71.0	7.08	8.17
Plant height (cm)	131.21	167.28	146.06	2.32	3.66	40.0	4.52	3.02
Days to 50% flowering	94.95	107.28	98.98	1.4	2.31	37.0	1.72	1.76
Number of branches plant^{-1}	10.07	18.40	14.07	5.87	9.58	38.0	1.14	7.42
Number of umbels plant^{-1}	101.15	170.41	126.52	2.61	4.4	35.0	4.08	3.19
Number of umbellets per umbel	30.86	42.52	36.80	3.51	5.09	48.0	1.79	4.99
Weight of grains per umbel (g)	0.55	0.93	0.70	3.40	5.20	43.0	0.04	0.06
Test weight (g)	4.39	7.70	6.30	4.51	7.41	37.0	0.37	5.65
Days to maturity	223.89	237.22	230.33	0.63	1.0	40.0	1.87	0.82
Seed yield plant^{-1} (g)	10.82	78.98	38.31	14.27	18.05	62.0	8.66	23.24
Seed yield (q ha^{-1})	5.70	13.47	9.78	3.28	5.37	37.0	0.44	4.12

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