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Studies on genetic variability, heritability and genetic advances in fenugreek (*Trigonella foenum-graecum* L.)

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Abstract
The experiment was carried out on 123 accessions which were evaluated to estimates of genetic variability, heritability and genetic advances in fenugreek. High coefficients of variation were estimated for days to 50 percent flowering followed by primary branch per plant and length of pod, while, lower coefficients of variation were recorded for number of pod per plant. The highest heritability (broad sense) was observed for day to 50 percent flowering (92.11%) followed by seed per pod (91.65%) and length of pod (91.15%). High heritability coupled with high genetic advance was recorded for day to 50 percent flowering followed by length of pod. When variability, heritability and genetic advance are considered together day to 50 percent flowering and length of pod may be the best table traits that could be exploited for hybridization and selection for improvement since these characters recorded high variability, high heritability and high to moderate genetic advance.

Keywords: Fenugreek, variability, heritability and genetic advance

Introduction
Fenugreek, commonly called Greek hay or 'methi', is the dried ripe fruit of the pulse, *Trigonella foenum-graecum* Linn. (2n=16), belongs to family papilionaceae. India occupies a prime position among the fenugreek growing countries of the world. Fenugreek is a herb which is commonly found to be growing in the Mediterranean region of the world. Fenugreek can be grown in the tropics and in temperate regions. It is grown from sea level up to an altitude of 2000m.

Botanically, the genus *Trigonella* comprises 50 species, mostly of Mediterranean and Oriental origin. There are two species of the genus *Trigonella*, which have economic importance, *viz.*, *Trigonella foenum-graecum* or the commonly called 'methi' and *Trigonella corniculata* or the "kasuri methi." Fenugreek is an annual herb, 30 to 90 cm tall and has light green leaves which are pinnately trifoliate. The flowers are papillenaceaus and white or yellow in colour and produces slander, beaked pods of approximately 10-15 cm long and each pod contains 10-20 small hard yellowish brown seed possessing smooth and oblong, about 3 mm long, each grooved across one corner, giving them a hooked appearance.

In India, fenugreek is grown in about 149(000 ha) with an annual production of about 202(000 MT) (Anonymous 2018) [2]. Major producing states are Rajasthan, Madhya Pradesh, Gujarat, Uttar Pradesh and Tamil Nadu but Rajasthan claims the monopoly in production accounting for about 80% of fenugreek produce in the country During 2017-2018, These crops play an important role in our national economy (Devakaran, 1989, Singh and Singh, 1996). However, national to the domestic need and the export target beyond 2000 A.D., their production requirement is 3-4 folds, up-gradation of the existing level (Thomas *et al.* 1989, Edison and Johny 1991 and Peter, 1996). Fenugreek is grown during *Rabi* or winter season as a leafy vegetable. Its seeds or leaves are used for human consumption (Som and Maity, 1986, Pandey, 1993), fodder for the animal (Jatasra and Lodhi, 1980) and green manure to enrich the soil fertility through nitrogen fixation, *i.e* about 283 kg N/ha (Gill & Singh, 1988 and Kohli, 1983). The leaves and shoots are quite rich in protein, minerals and vit. A and C. Fenugreek seed contain protein (25.5%), fat (7.9%), mucilaginous matter (20%) and saponins (4.8%). The seeds also contain cellulose, hemicelluloses and major nutrients like phosphorus, potassium and mineral nutrients like calcium, iron and sodium, amino acids like leucine, valine, lysine and phenylalanine. Due to its mucilaginous, demulcent, diuretic, carminative, astringent, emollient and aphrodisiac properties of seeds are also used in preparation of several ayurvedic medicines.

Fenugreek is used both as whole seed and in powdered form and often roasted to reduce its bitterness and enhance the flavor. Seeds are bitter in taste due to presence of an alkaloid "*Trigonelline*". The importance of fenugreek has further increased due to presence of a steroid called "*Diosgenin"*. *Diosgenin* is used in the synthesis of sex hormones and oral contraceptives. Further the crop attracted the attention of the farmers and agricultural scientist due to high remunerative prices.

To work out efficient breeding programmes, knowledge regarding the presence of genetic variability for yield and its component traits is required. Besides genetic variability, heritability and genetic advance also plays a important role for the improvement of any character. Selection and hybridization approaches are easily followed in bringing about the quantitative improvement in desired traits. 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. Very little information is available in this direction on fenugreek. Keeping this in view, an attempt was made in the present investigation to assess the magnitude of variability, heritability and genetic advance for different characters in fenugreek germplasm.

Materials and methods

The present investigation was conducted during *Rabi* season, 2018-19 at Main Experimental Station (Vegetable Research Farm), Acharya Narendra Deva University of Agriculture and Technology Narendra Nagar (Kumarganj), Ayodhya (U.P.) India. The experimental materials comprised of 123 fenugreek genotypes among which 3 were the check variety. Each genotype was planted in a plot having 2 x 1.20 m^2 area with row to row spacing of 30 cm and plant to plant spacing of 10 cm in randomized block design. All the standard package of practices and plant protection measures were timely adopted to raise the crop successfully. Five randomly selected plants from each plot were utilized for recording observations and drawing sample for estimating variability, heritability and genetic advance. The observations were recorded on days to 50 per cent flowering, day to maturity, Plant height, number of primary branches per plant, number of secondary branches per plant, pods per plant, seeds per pod, length of pod, 1000-seed weight and seed yield per plant. Phenotypic and genotypic coefficients of variation were estimated according to (Burton and Devane, 1953). Heritability in broad sense was estimated by (Hanson *et al.*, 1956). The extent of genetic advance and genetic advance as percentage over mean were worked out using the formula suggested by (Robinson, 1965).

Results and discussion

Analysis of variance for ten morphological traits reveled significant differences between the genotypes for all trait under study. The values of mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability, genetic advance and genetic advance expressed as per cent mean for all the characters studied are presented in Table 1.

The estimate of genotypic coefficient of variation is of prime importance to breeder because genetic variance alone does not allow a decision as to which characters were showing the highest degree of variability. Therefore, accurate relative comparison can be made with the help of phenotypic and genotypic coefficients of variation

Phenotypic coefficient of variance ranged from 8.793% (number of pod per plant) to 26.43% (day to 50 percent flowering). Genotypic coefficient of variance ranged from 7.599% (number of pod per plant) to 25.48% (day to 50 percent flowering). The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the characters. High magnitude of genetic coefficient of variance and phenotypic coefficient of variance was observed in case of days to 50 percent flowering followed by primary branch per plant, length of pod. These results are in agreement with earlier reports for number of branches per plant and length of pod by Kumar *et al.*, 2018. The result indicates presence of very high degree of variability and better scope for improvement.

Moderate to high genotypic coefficient of variance and phenotypic coefficient of variance were recorded for, seed per pod and plant height. These results are agreement with the earlier findings for plant height by Yadav *et al.* (2018).

Moderate GCV along with PCV were recorded for, day to maturity, secondary branches per plant, 1000-seed weight, seed yield per plant. While the phenotypic and genotypic coefficients of variations were lower for number of pod per plant. Similar results are agreement with the earlier finding for number of pod per plant by Dashora *et al*. (2012) Narrow differences between PCV and GCV gave evidence to the lines that the variability exiting in them was mainly due to their genetic makeup.

The estimate of heritability ranged from 71.30% (days to maturity) to 92.11% (days to 50 per cent flowering). The heritability was found to be higher for the characters namely day to 50% flowering followed by number of seed per pod, length of pod, seed yield per plant and number of pod per plant. Similar observations were made by Maurya *et al*. (2013) [27], Mamatha *et al*. (2017) [26], Singh *et al*. (2019) for the trait number of seed per pod, length of pod, seed yield per plant and number of pod per plant.

Johnson *et al*. (1955) indicated that a high heritability is not always an indication of high genetic gain. Swarup and Chaugale (1962) also showed that high heritability is not always an indicator of genetic gain. High heritability and high genetic advance are important for the improvement (genetic gain) of any character. Heritability estimates in broad sense when used in conjunction with the genetic advance would give better information than the heritability alone. In the present study, high heritability coupled with the high genetic advance as per cent mean were noted for day to 50 percent flowering followed by length of pod and seed yield per plant. Similar observations were recorded by Pathak *et al*. (2014), Kumar *et al*. (2018) and Singh *et al*. (2019).

High heritability along with moderate genetic advance was recorded in number of seed per pod. Moderate heritability along with high genetic advances are observed in number of primary branches per plant and plant height. Moderate heritability coupled with low genetic advances are recorded in secondary branches per plant.

Table 4.3: Estimates of range, grand mean, phenotypic (PCV) and genotypic (GCV) coefficient of variation, heritability in broad sense $h^2_{(bs)}$ in per cent, genetic advance in per cent of mean ($\overline{Ga}$ %) for ten characters in fenugreek genotypes.

Character	Range		Grand Mean ($\bar{x}$)	PCV (%)	GCV (%)	Heritability broad sense [h^2%]	Genetic advance	Genetic advance in per cent of mean ($\overline{Ga}$ %)
	Minimum	Maximum						
Days to 50% flowering	64.50	79.50	71.93	26.43	25.48	92.11	5.654	37.235
Days to maturity	118.50	135.50	127.16	9.126	8.55	71.301	8.334	15.765
Plant height (cm)	65.60	105.80	86.69	11.256	10.467	85.367	5.953	17.647
Primary branches/plant	1.80	4.20	3.17	14.49	13.356	77.348	3.732	20.642
Secondary branches/plant	3.80	7.80	5.64	10.845	9.541	85.231	2.658	7.685
Pods/plant	10.80	42.20	23.71	8.793	7.599	87.286	7.467	3.275
Length of pod (cm)	7.98	14.02	11.17	13.334	12.075	91.154	18.564	22.543
Seeds/pod	15.00	25.00	19.30	11.977	10.426	91.649	12.943	15.942
1000-seed weight (g)	5.83	11.98	8.72	9.755	8.376	71.51	7.883	10.661
Seed yield/plant (g)	2.09	8.13	4.67	10.38	8.341	88.16	6.867	19.245

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