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To estimate heritability and genetic advance in percent of mean in germplasm of fenugreek [*Trigonella foenum-graecum* L.]

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Abstract
The field experiment was laid out in Augmented Block Design with 120 genotypes along with three checks in six blocks. The present investigation was conducted during November 2015 to March 2016 at Main Experimental Station of Vegetable Science, Narendra Deva University of Agriculture & Technology, Kumarganj, and Faizabad (U.P.). The characters studied were Days to 50% flowering, days to maturity, plant height (cm), number of branches per plant, number of pods per plant, length of pod (cm), number of seed per pod**,** 1000 seed weight (g)**,** seed yield per plant (g) and yield (q/ha). Data were analyzed statistically for their mean, range, coefficient of variation, heritability, genetic advance, and genetic advance as percent of mean using non-hierarchical Euclidean cluster analysis. The study revealed genetic variation for all studied traits in fenugreek. Analyses of variance for the design of experiment of fenugreek showed that block were highly significant for all the characters. The P.C.V. was higher in magnitude than G.C.V. The maximum genotypic and phenotypic variances were observed for branches per plant and plant height. Heritability estimates were high for 1000-seed weight (g), Number of pods /plant, Days to maturity. Number of branches / plant, Plant height (cm) and Plant height (cm) showed very high genetic advance in percent of mean. In present study, pods per plant showed positive and highly significant correlation association with seed yield (q/ha). Path coefficient analysis carried out at genotypic as well as phenotypic level revealed pods per plant, seed per pod and 1000 seed weight had positive direct effect on seed yield per plant, this indicates that selection for these traits will be useful.

Keywords: Genetic variability, GCV, PCV, heritability, genetic advance

Introduction
Mainly 52 spices are grown in India according to Spices Board, Calicut, Kerala. Fenugreek is one of the important seed spices crop grown throughout the world. India occupies a prime position among the fenugreek growing countries of the world. Fenugreek is both a tropical and temperate crop. It has a wide adaptability and is grown in a wide range of climatic condition. It is tolerant to frost and freezing weather. It is grown from sea level up to an altitude of 2000 m. The crop is adopted to all type of soil, but its performance is good in well drained loamy soils. The optimum pH should be 6.0-7.0 for its better growth and development.

Fenugreek (*Trigonella foenum-graecum* L.) is a native of South-Eastern Europe and west Asia. The genus *Trigonella* comprises 50 species, mostly of Mediterranean and Oriental origin. It is grown wilds in part of North India and is cultivated all over the subcontinent for the green leaves and seeds. Its wild forms are found in north-western India. The species *Trigonella polycerata* L. grows wild in India. It is cultivated as a leafy vegetable, condiment and as medicinal plant. The seeds are good for the elimination of bad breath and body odour. The seeds are used in colic flatulence, dysentery, diarrhea, dyspepsia with loss of appetite, chronic cough, dropsy, enlargement of liver and spleen, rickets, gout and diabetes. The seeds are carminative, tonic and aphrodisiac. Fenugreek seeds substantially contain Diosgenin which is the precursor of steroids, including sex hormones and oral contraceptives. The content varies from 0.40-1.26% in seeds. Fenugreek also helps to combat dandruff and is a cure for baldness in man. Indian women use the seeds of fenugreek for its power to promote lactation. Besides young green tender plant and leaves are also used as nutritionally rich the vegetable. Fenugreek which form the actual spice is rich source of vitamin A, C and B2 (Aykroyd, 1963) [1], protein (Rao and Sharma 1987) [11].

Seed contains diosgenin which is used in the preparation of contraceptive pills. Fenugreek is an annual herb, 30 to 90 cm tall and has light green leaves which are pinnately trifoliate. The flowers are papillonaceaus and white or yellow in colour. Anthesis takes place between 9AM to 6PM with a peak at 11.30AM. The anthers dehisce between 10.30AM to 5.30PM with a peak between 11.30AM to 12.30NOON. Stigma become receptive 12 hours before flower opening and remains receptive for about 10 hours after the opening of flowers. The plants flower in about 30-37 days after sowing and the duration of flowering phase in 7-18 days. The species is typically self-pollinated and cleistogamous. Pollen fertility ranges from 95-98% in the unopened flower buds and 67-80% in the open flowers. The 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. Fruits are legumes, long, narrow, curved and are tapering with a slender point which contains small deeply furrowed seeds. The pods mature within 60-70 days of sowing. In the plains seeds are sown during September to November and in the hills in March-Aril. In southern India it is grown in both *kharif* and *rabi* (early October). Seed or leaf spices for human consumption (Som and Maity, 1986, Pandey, 1993) [16, 10], fodder for the animal (Jatasra and Lodhi, 1980) [8] and green manure to enrich the soil fertility through nitrogen fixation, *i.e.*above 283 kg N/ha (Gill & Singh, 1988 and Kohli, 1983) [6, 9]. Inoculation of seeds with *Rhizobium* culture before sowing is beneficial to the crop for fixing atmospheric nitrogen. The genetic improvement of any crop depends upon its judicious exploitation through efficient breeding methods. Few high yielding varieties dominate in cultivation which often leads to genetic homogeneity. It is also well established that genetic homogeneity leads to genetic vulnerability to biotic and abiotic stresses. In any crop breeding programme, germplasm serve as the most valuable reservoir in providing variability for various traits. Most of the economically important plant characters are polygenic. Number of seeds per pod, seed weight and fodder yield were found to have high heritability. Plant height, days to flowering and yield per plant had moderate to low heritability. Pod length and pod per plant were observed to be highly heritable characters according one report while these had moderate to low heritability in another study. The double pod character had high heritability with additive, dominance and epistasis effects. 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. Beside knowledge of inter-character association and direct and indirect effect on seed yield is also essential. Exotic introductions are low yielders. Algerian and Morocco types contain relatively higher level of 'Diosgenin'. Selection play a predominant role in crop improvement of fenugreek and most of the high yielding varieties are made out of selection from germplasm.

Materials and Methods

The present investigation was carried out during Rabi season of 2015-16 at Main Experiment Station (Vegetable Research Farm), of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.) India. The experiment was conducted in Augmented Block Design. The material used in the experiment comprised of 120 selected germplasm lines of fenugreek and three checks. Geographically the experimental site falls under humid subtropical climate and is located at 260 47′ N latitude and 820 12′ E longitudes at an elevation of altitude of 113 meter above the mean sea level. Geographically it falls in north east gangetic alluvial plains of eastern U.P. Faizabad region. The climate of district Faizabad is semi-arid with hot summer and cold winter. Maximum rains in this area are received from July to the end of September. The winter months are usually cool and dry but occasional light showers are also not uncommon whereas, summer months are extreme hot and dry. The data was recorded at meteorological observatory of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.) One hundred twenty genotypes of fenugreek maintained in All India Co-ordinated Research Project on Spices were taken for this investigation. These Narendra Methi (NDM-1) to genotypes Narendra Methi (NDM-120) were collected from Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad, Uttar Pradesh. The check varieties were Hisar Sonali (C.C.S.H.A.U., Hisar, Haryana), PEB (IARI, New Delhi) and Rajendra Kranti (R.A.U., Bihar). A random selection of five plants was made in each plot for recording the observations on different characters under study. The experimental materials were evaluated in Augmented Block Design (ABD) with spacing of 30cm × 10cm with plot size of 2.0m ×1.2m. The observations were recorded on ten quantitative characters *viz.* days to 50 percent flowering, days to maturity, plant height, branches per plant, pods per plant, length of pod, seeds per pod, 1000-seed weight (g), seed yield per plant (g) and seed yield (q/ha). Mean data for each trait was used for statistical analysis. The statistical analysis was done by using the techniques of analysis of "Augmented Block Design". These designs were developed by Federer (1956) [5]. The analysis of variance for different characters in augmented design was done following Federer (1956) [5]. Variability of different characters was estimated as suggested by Burton and de Vane (1953) [3]. The correlation coefficients were calculated to determine the degree of association of characters with yield. Genotypic and phenotypic correlations coefficients were estimated according to the formula given by Searle (1964). Heritability (h^2) in broad sense was calculated by using the formula suggested by Hanson *et al.* (1956) [7].

Result and Discussion

The heritability in broad sense (Hanson *et al*., 1956) [7] and genetic advance in percent of mean (Johnson *et al.*, 1955) are calculated for understanding the transmissibility of characters. The nature of associations among different character is studies by using phenotypic and genotypic correlation coefficient (Searle, 1961) [12] and Path coefficient analysis (Dewey and Lu, (1959) [4]. Heritability in broad sense [$h^2_{(bs)\%}$] and genetic advanced in percent of mean ($\overline{Ga}$%) for all the ten characters were estimated and findings are given in table-1. The magnitude of heritability in broad sense varied between - 98.84% in case of 1000-seed weight to 38.13% for length of pod. The high estimates of heritability (h^2b) (>75%) were noted for 1000-seed weight (98.84), pods per plant (96.34%), days to maturity (95.77%), branches per plant (95.45%), plant height (94.27%), seed yield (q/ha) (90.92%), seed yield per plant (90.91%), seeds per pod (84.18%), while days to 50% flowering (38.57%) and length of pod(38.13%) showed low heritability (<50%).

Genetic advance in percent of mean ranged from 44.21%, (branches per plant) to 1.59, (days to 50% flowering). The very high estimates of (>20%) genetic advanced was registered for branches per plant (44.21%), plant height (39.14%), Pods per plant (31.27%), seed yield (q/ha) (29.84%), seed yield per plant (29.72%), 1000-seed weight (25.25%) and seeds per pod (22.86%) whereas, length of pod (6.00%), days to maturity (4.14%), and days to 50% flowering (1.59%) possessed low genetic advanced (<10%).

The fundamental principal involved in plant breeding is the application of selection on the genetic variability available in germplasm for various characters to change the genetic architecture of the plant character and consequently of plant in order to develop improved genotypes possessing higher economic yield and value than existing ones. Obviously, genetic variability is the raw material on which selection acts to bring improvements in genetic architecture of plants. Heritability in broad sense [$h^2_{(bs)\%}$] and genetic advanced in percent of mean (**$\overline{Ga}$**) as direct selection parameters provides index of transmissibility of traits which gives indication about the effectiveness of selection in improving the characters.

Table 1: Estimates of range, grand mean, phenotypic (PCV) and genotypic (GCV) coefficient of variation, heritability in broad sense [$h^2_{(bs)}$%], genetic advance in percent of mean ($\overline{Ga}$%) for ten characters in Fenugreek genotypes

S. No.	Characters	Range		Grand mean	PCV (%)	GCV (%)	Heritability broad sense (%) (h^2_{bs})	Genetic advance	Genetic advance in percent of mean (Ga)
		Lowest	Highest						
1	Days to 50% flowering	65.00	77.67	70.12	2.01	1.25	38.57	1.12	1.59
2	Days to maturity	123.67	135.67	128.58	2.10	2.05	95.77	5.33	4.14
3	Plant height (cm)	24.33	103.33	60.85	20.16	19.57	94.27	23.82	39.14
4	Number of branches / plant	2.67	13.00	5.36	22.48	21.96	95.45	2.37	44.21
5	Number of pods /plant	24.00	60.67	33.96	15.75	15.46	96.34	10.62	31.27
6	Length of pod (cm)	6.67	14.67	11.16	7.65	4.72	38.13	0.67	6.00
7	Number of seed /pod	7.33	23.33	15.61	13.19	12.11	84.18	3.57	22.86
8	1000-seed weight (g)	4.80	10.60	6.93	12.37	12.30	98.84	1.75	25.25
9	Seed yield/plant (g)	2.60	6.00	3.70	15.89	15.15	90.91	1.10	29.72
10	Yield (q/ha)	8.67	20.00	12.33	15.92	15.18	90.92	3.68	29.84

The high estimates of heritability with low genetic advanced in percent of mean was observed for 1000-seed weight (h^2b%= 98.84%, Ga%= 25.25%). The character, mentioned above, having high values of heritability and low genetic advanced in percent of mean emerged as ideal traits for improvement through hybridization because it has non-additive gene action. The pods per plant (q/ha) (h^2b%= 96.34%, Ga%= 31.27%), days to maturity (h^2b%= 95.77%, Ga%= 4.14%), branches per plant (h^2b%= 95.45%, Ga%= 44.21%), plant height (h^2b%= 94.27%, Ga%= 39.14%) showed moderate GCV and PCV values which suggested that the genotypes evaluated and/or segregating derived from them may provide response to selection for the characters exhibiting moderate heritability along with moderate genetic advanced owing to their moderate transmissibility and variability. seed yield (q/ha) (h^2b%=90.92%, Ga%=29.84%), seed yield per plant (h^2b%=90.91%, Ga%=29.72%), Seeds per pod (h^2b%= 84.18%, Ga%= 22.86%), days to 50% flowering (h^2b%= 38.57%, Ga%= 1.59%), and length of pod (h^2b%= 38.13%, Ga%= 6.00%) showed moderate to low PCV and low GCV which show non-additive gene action in these characters the improvement are possible through hybridization.

Shukla and Sharma (1978) [14] reported moderate to low heritability (in broad sense) for days to flowering, plant height, pods per plant, pod length and seed yield per plant and high heritability for test weight of seed in fenugreek. The genetic advance was also considerably high for test weight and yield per plant. Baswana *et al.* (1984) [2] observed high heritability along with high genetic advance in yield per plant, seeds per pod, branches per pod and plant height. Sharma *et al.* (1990) [13] reported broad sense heritability in fenugreek for 11 characters. They reported high heritability > 40 for days to flowering, pods per plant, straw and grain yield per plant and moderate to low for plant height, branches/ plant, days to maturity and pod length. Singh and Pramila (2009) [15] high heritability for 1000-grain weight, length of pod, number of days to 50% flowering and number of grains per pod. The genetic advance was also considerable high for yield per plot and number of seeds per pod.

Conclusion

Based on overall findings of the present study, it was concluded that there was a wide range of variation among the germplasm lines for all the characters indicating that considerable scope existed for the improvement of fenugreek cultivars through selections. Genetic parameters in association with correlation study indicated that for selection of superior genotypes primary, emphasis should be given on pods per plant, seeds per pod and length of pod. Out of one hundred twenty genotypes and three checks NDM-1, followed by NDM-28, NDM-25, NDM-119, NDM-4, NDM-7, NDM-2, NDM-11 and NDM-49 were found superior for yield and these germplasm may be recommended for large scale cultivation among the farmers after proper testing in multi-location trials and these superior genotypes can be used as donors in breeding programme.

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