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Quantitative analysis of selection parameters in yield contributing traits of fenugreek (*Trigonella foenum-graecum* L.) genotypes

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Abstract
The present experiment was conducted with one hundred twenty fenugreek genotypes for ten characters was laid out in Augmented Block Design at Main Experimental Station of Vegetable Science, Narendra Deva University of Agriculture & Technology Kumarganj, Faizabad (U.P.) during November 2013 to April 2014. The characters studied were days to 50% flowering, days to maturity, plant height (cm), branches per plant, pods per plant, length of pod (cm), seeds per pod, 1000 seed weight (g), seed yield per plant (g) and seed yield (q/ha). The study revealed genetic variation for all studied traits in fenugreek. Analyses of variance for the design of experiment of fenugreek showed that replication 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 pods per plant. Heritability estimates were high for length of pod (cm), seed yield (q/ha), seed yield per plant (g) and seeds per pod. Branches per plant and pods per plant showed very high genetic advance in per cent 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, seeds 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: fenugreek (*Trigonella foenum-graecum* L.), phenotypic coefficient of variation (PCV)

Introduction
Fenugreek, commonly called Greekhayes or "Methi", is the dried ripe fruit of the pulse *Trigonella foenum-graecum* Linn. (2n=16), belongs to family Fabaceae. 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.

Among the seed spices, fenugreek (*Trigonella foenum – graecum*) belongs to family Fabaceae, 2n=16 (Fryer, 1930). It has been originated in Egypt. It's wild forms are found in north western India. On the other hand, Argentina, Egypt, Southern France, Morocco, Spain, Turkey, China, Pakistan and Lebanon are the leading countries for fenugreek production.

India has been known as land of spices since very early period of recorded history. The history of Indian spices is known to be dates back to the beginning of human civilization. Moreover, references are also available with regard to Indian spices and their use in Vedas (6000 B.C.) by Manu (4000 B.C.). According to the Bureau of Indian Standard, 63 kinds of spices are grown in the country on 81.2 million hectare and produce 118.4 million tonnes of spices in a year (National Horticulture Board, 2013-14). The value of these spices including spices product such as oils, oleoresins and curry powder amount to over 4200 crores (Spices Board, Kochi). Among the spices crops, the seed spices from an important group of crop which are extensively grown throughout the country as pure or intercrop, both under rainfed and irrigated conditions. These crops play an important role in our national economy. However, national to the domestic need and the export target beyond 2000 A.D., their production requirement is 3-4 folds, upgradation of the existing level. However, in India it is mainly grown in Rajasthan, Madhya Pradesh, U.P., Gujarat and Punjab. Rajasthan claims the monopoly in production accounting for about 80% of fenugreek produce in the country. The seeds are used as spices and condiment to improve the flavour and nutritive value of food, fried seed with a small quantity of oil is used for seasoning vegetables. Being due to its mucilaginous, demulcent diuretic, carminative, astringent, emollient and aphrodisiac

properties of seeds are also used in preparation of several ayurvedic medicines. 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 B_2 protein (Rao and Sharma 1987). Seed contains diosgenin which is used in the preparation of contraceptive pills. Along with it's another cultivated species *Trigonella corniculata* L. commonly known as *kasuri* or *champamethi* differing in growth habit / pod seed size and yield potential served as multipurpose crop. Fenugreek is grown during *Rabi* or winter season as a leafy vegetable. Seed or leaf spices for human consumption, fodder for the animal and green manure to enrich the soil fertility through nitrogen fixation, *i.e* above 283 kg N/ha.

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. Proper screening and evaluation of germplasm lines would provide an estimate about their potential value as suitable genotype for utilization in varietal development programme.

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.

Materials and Methods

The experimental material comprised of One hundred twenty genotypes of fenugreek maintained in All India Co-ordinated Research Project on Spices was taken for this investigation. These Narendra Methi (NDM-1) to genotypes Narendra Methi (NDM-121) were collected from Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad, Uttar Pradesh.

The check varieties were PEB (IARI, New Delhi), NDM-19 (N. D. Univ. of Agri. & Tech., Faizabad, U. P.) and Hisar Sonali (C.C.S.H.A.U., Hisar, Haryana). The experiment was conducted in Augmented Block Design. The material used in the experiment comprised of 120 selected germplasm lines of fenugreek.

A random selection of five plants was made in each plot for recording the observations on different characters under study. The following observations were recorded during the course of experimentation. Observations on the following were recorded using the standard procedure: Days to 50% flowering, Days to maturity, Plant height (cm), Branches per plant, Pods per plant, Length of pod (cm), Seeds per pod, 1000-seed weight (g), Seed yield per plant (g), Seed yield (q/ha). The genotypic and phenotypic variances were calculated according to Johnson *et al.* (1955) [3] and Comstock and Robinson (1952) [3]. Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were calculated by the Burton and de Vane (1953). Heritability (Hanson *et al.* 1963) [2] and Genetic advance in percent of mean (Johnson *et al*. 1955) [3].

Results and Discussion

The analysis of variance of the experiment indicated highly significant differences among the one hundred twenty genotypes for all the traits except non-significant differences for days to maturity, in variance due to block. The analysis of variance of the experiment indicated highly significant differences among the genotypes (Shukla and Sharma 1978) [6] for all the traits except non-significant differences for plant height, branches per plant, seeds per pod and 1000-seed weight, in variance due to checkand indicated presence of considerable amount of variability in the genotypes (Table-1). The estimates of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for ten seed quality characters of Fenugreek germplasm are presented in Table-2. The magnitudes of phenotypic coefficient of variation (PCV) was higher than the corresponding genotypic coefficient of variation (GCV) for all the seed quality traits. The phenotypic coefficient of variation was estimated for one hundred twenty genotypes for ten characters. The number of branches per plant (19.98%) showed highest phenotypic coefficient of variation followed by pods per plant (12.30%), seed yield q/ha (8.33%), seed yield per plant (8.32%), plant height (7.58%), seeds per pod (6.61%), length of pod (4.85%), and 1000-seed weight (4.82%) (Shukla and Sharma 1978, Raghuvansi and Singh 1982, Reddy *et al.* 1991, Mehta *et al.* 1992, Kole and Mishra 2006, Naik *et al.* 2011, Fikreselassie *et al.* 2012, Singh *et al.* 2014) [6, 8, 20, 22, 24, 29, 33, 38, 11]. The remaining two characters *viz.*, days to 50% flowering and days to maturity showed low value of PCV (Kailash Chandra 1992, Meena 1994) [14, 34]. The estimate of genotypic coefficient of variation (GCV) for ten characters *Viz.*, branches per plant (15.49%), pods per plant (10.18%), showed highest GCV; seed yield q/ha (6.92%), seed yield per plant (6.91%), seed per pod (5.10%), plant height (4.45%), length of pod (4.32%) has medium genotypic coefficient of variation; 1000-seed weight (3.89%) and days to 50% flowering (1.48%) exhibited low genotypic coefficient of variation (Shukla and Sharma 1978, Raghuvansi and Singh 1982, Reddy *et al.* 1991, Mehta *et al.* 1992, Kole and Mishra 2006, Naik *et al.* 2011) [6, 20, 22, 24, 29, 33]. On the other hand days to maturity (-1.60%) exhibited negative genotypic coefficient of variation.

Heritability in broad sense [$h^2_{(bs)\%}$] and genetic advanced in per cent of mean **($\overline{Ga}$ %)** for all the ten characters were estimated and findings are given in Table 3.

The magnitude of heritability in broad sense varied between -145.23% in case of length of pod to 79.36% for days to maturity. The high estimates of heritability (h^2b) (>75%) were noted for length of pod (76.36%) (Baswana *et al.* 1984, Reddy *et al.* 1991) [20, 12]. Moderate estimates of heritability (>50-75%) were recorded for seed yield (q/ha) (69.09%), seed yield per plant (68.90%), pods per plant (68.56%), seeds per pod (68.51%), 1000-seed weight (64.91%), branches per plant (60.09) and days to 50% flowering (58.75%) (Shukla and Sharma 1978) [6] while plant height (34.44%) and days to maturity (-145.23%) showed low heritability (<50%) (Kailash Chandra 1992) [24].

Genetic advance in per cent of mean at 5% and 1% level of significance respectively, ranged from 24.73%, 31.69% (branches per plant) to -3.97, -5.09 (days to maturity). The very high estimates of (>20%) genetic advanced was registered for branches per plant (24.75%, 31.69%). Pods per plant (17.37%, 22.26%), seed yield (q/ha) and seed yield per plant (11.81%, 15.13%) (Shukla and Sharma 1978, Baswana *et al.* 1984, Pant *et al.* 1984, Reddy *et al.* 1991, Singh 2014)

[20, 11, 12, 21] exhibited moderate genetic advance (10-20%), whereas, seeds per pod (8.96%, 11.14%), length of pod (7.93%, 10.16%), 1000-seed weight (6.45%, 8.72%), plant height (5.38%, 6.89%) and days to 50% flowering (2.34%, 3.00%) possessed low genetic advanced (<10%) (Kailash Chandra 1992, Sharma *et al.* 1990) [24].

Wide spectrum of variation was observed for yield (Rao and Babu 1981) [7] characters of one hundred twenty fenugreek genotypes. High magnitude of genotypic and phenotypic coefficients of variation was observed for branches per plant, indicating thereby, substantial scope for improvement in this character after hybridization and subsequent selection. Moderate estimates of GCV and PCV were observed for pods per plant which suggested possibility of obtaining reasonable improvement through selection. Minimum variation was observed between phenotypic coefficient of variation and genotypic coefficient of variation in majority of the traits indicating least influence of environmental factors which reflects that certain genotypes matured late 142.61 days (NDM-24). The high estimate of heritability with low genetic advance in per cent of mean was observed for length of pod (h^2b= 79.36%, Ga%= 7.93%). The character, mentioned above, having high values of heritability and low genetic advanced in per cent of mean emerged as ideal traits for improvements through hybridization. Seed yield per plant (h^2b= 69.09%, Ga%= 11.85%), seed yield (q/ha) (h^2b= 68.90%, Ga%= 11.81%) and pods per plant (h^2b= 68.56%, Ga%= 17.37%) showed moderate heritability coupled with moderate genetic advance in per cent of mean which indicated possibility of obtaining reasonable response to selection in these owing to their moderate transmissibility. Branches per plant showed moderate heritability with high genetic advance in per cent of mean possessing non-additive gene action, also indicated moderate transmissibility for improvements through selection.

Table 1: Analysis of variance for ten characters in Fenugreek genotypes

Character	Source of variation		
	Replication	Treatment	Error
	11 (d. f.)	2 (d. f.)	22 (d. f.)
Days to 50% flowering	2.87**	61.08**	0.90
Days to maturity	1.80	499.36**	8.39
Plant height (cm)	105.19**	24.34	19.12
Branches/plant	1.10**	0.55	0.19
Pods/plant	45.95**	413.4**	4.87
Length of pod (cm)	0.95**	2.13**	0.06
Seeds/pod	3.81**	0.33	0.30
1000-seed weight (g)	0.62**	0.19	0.07
Seed yield/plant (g)	0.18**	9.01**	0.05
Seed yield (q/ha)	1.59**	81.05**	0.44

*; ** significant at 5% and 1% probability levels, respectively

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

Character	Range (Lowest-Highest)	Grand Mean ($\bar{x}$)	PCV (%)	GCV (%)	Heritability [$h^2_{(bs)}$%]	Genetic advance in per cent of mean ($\overline{Ga}$ %)	
						at 5%	at 1%
Days to 50 flowering	72.58-80.25	76.27±0.14	1.94	1.48	58.75	2.34	3.00
Days to maturity	126.28-142.61	139.14±0.18	1.33	-1.60	-145.23	-3.97	-5.09
Plant height (cm)	46.71-85.34	71.26±0.64	7.58	4.45	34.44	5.38	6.89
Branches/plant	1.03-4.99	3.42±0.07	19.98	15.49	60.09	24.73	31.69
Pods/plant	23.73-45.44	32.01±0.39	12.30	10.18	68.56	17.37	22.26
Length of pod (cm)	8.96-12.49	11.07±0.06	4.85	4.32	79.36	7.93	10.16
Seeds/pod	13.17-17.9	15.84±0.09	6.16	5.10	68.51	8.69	11.14
1000-seed weight (g)	7.96-10.94	9.49 ±0.05	4.82	3.89	64.91	6.45	8.27
Seed yield/plant (g)	3.65-5.87	4.78±0.04	8.32	6.91	68.90	11.81	15.13
Seed yield (q/ha)	10.95-17.61	14.32±0.12	8.33	6.92	69.09	11.85	15.19

Table 3: The most promising genotypes identified for ten characters

Character	Genotypes
Days to 50% flowering	NDM-7, NDM-20, NDM-23, NDM-4, NDM-6, NDM-17, NDM-28, NDM-32, NDM-106, NDM-109, NDM-115, NDM-116, NDM-118, NDM-121
Days to maturity	NDM-75, NDM-34, NDM-71, NDM-1, NDM-32, NDM-37
Plant height (cm)	NDM-36, NDM-68, NDM-104, NDM-8, NDM-89, NDM-102, NDM-88, NDM-90, NDM-103, NDM-73, NDM-5, NDM-87, NDM-17, NDM-35, NDM-63, NDM-107, NDM-43, NDM-3
Branches/plant	NDM-67, NDM-2, NDM-6, NDM-104, NDM-15, NDM-94, NDM-118, NDM-109, NDM-79, NDM-107, NDM-14, NDM-63, NDM-68, NDM-8, NDM-114, NDM-116, NDM-21, NDM-39, NDM-41
Pods/plant	NDM-4, NDM-12, NDM-8, NDM-26, NDM-110, NDM-38, NDM-16, NDM-18, NDM-34
Length of pod (cm)	NDM-89, NDM-71, NDM-83, NDM-86, NDM-106, NDM-50, NDM-63, NDM-66, NDM-82, NDM-84, NDM-87, NDM-90, NDM-2
Seeds/pod	NDM-82, NDM-61, NDM-21, NDM-48, NDM-74, NDM-76, NDM-80, NDM-83, NDM-89, NDM-70, NDM-32, NDM-120, NDM-91, NDM-60, NDM-63, NDM-69, NDM-57, NDM-72, NDM-77, NDM-29, NDM-75
1000-seed weight (g)	NDM-47, NDM-100, NDM-101, NDM-95, NDM-44
Seed yield/plant (g)	NDM-18, NDM-64, NDM-69, NDM-16, NDM-12, NDM-4, NDM-11, NDM-25, NDM-115, NDM-8, NDM-45, NDM-83, NDM-67
Seed yield (q/ha)	NDM-18, NDM-64, NDM-69, NDM-16, NDM-12, NDM-4, NDM-11, NDM-25, NDM-45, NDM-83, NDM-67

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