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To study of correlation coefficient and path coefficient analysis for different characters 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 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. 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, correlation coefficient, path coefficient, genetic variation

Introduction
Fenugreek, commonly called Greekhayes or "Methi", is the dried ripe fruit of the pulse *Trigonella foenum-graecum* L. belongs to sub family Papilionaceae of the family Fabaceae, 2n=16. 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. 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 (Devakaran, 1989, Singh and Singh, 1996) [6, 12]. The leading countries of fenugreek production in the world are India, Argentina, Egypt, Southern France, Morocco, Spain, Turkey, China, Pakistan and Lebanon. 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. 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). 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. 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. Plant height, stem thickness and number of leaves per plant were positively correlated with yield of grains. Plant height, pods per plant, pod length and 250 seed weight had positive correlation with seed yield. Resistance to powdery mildew was governed by a single recessive gene. 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. Both chemical and physical mutagenic agents are useful for induction of mutation in fenugreek. The LD 50 for dry seed is 25kr and for soaked seed 20kr. In respect of Ethyle Methane Sulfonate (EMS) the LD 50 was 20M. Higher concentration of EMS leads to increased level of chromosomal aberrations. Concentrations around 0.4 and 0.6% are ideal for fenugreek. Tetraploids reveal higher values for many of the morphological characters. Seeds of tetraploids are larger but seed sterility is high. Yield is the end product of various characters, which directly or indirectly influence the growth of plant. The correlation coefficient gives an idea about the various associations existing between yield and yield components. Environment plays significant role on the expression of morphological and physiological characters including grain yield. Genotypic and environmental interaction effects are also predominant. The two characters, namely number of branches and pods per plant revealed high genotypic coefficient of variation, heritability estimate and genetic advance. These two characters also exhibit maximum correlation with grain yield. Hence these two characters serve as the useful selection indices. However the diosgenin content shows a negative relationship to that of grain yield.

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 per cent 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) [7]. The analysis of variance for different characters in augmented design was done following Federer (1956) [7]. Variability of different characters was estimated as suggested by Burton and de Vane (1953) [2]. Genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV) and environmental coefficient of variability (ECV). 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).

Results and Discussion

Correlation coefficient was worked out at phenotypic level for different traits in fenugreek (*Trigonella foenum-graecum* L.) genotypes are presented in Table-2. In general, the values of genotypic correlation coefficient are similar in nature and sign but slightly higher than phenotypic ones in magnitude for all the characters. Some of the characters had non-significant and negative correlation coefficients either at genotypic or phenotypic level. Highly significantly and positively phenotypic correlation of days to 50% flowering was estimated with branches per plant (0.217**). Days to 50% flowering were also showed non-significant and positive phenotypic correlation with rest of the characters. Days to maturity exhibited significantly and negatively phenotypic correlation with characters branches per plant (-0.275), 1000-seed weight (-0.299) and seed yield per plant (-0.247). Days to maturity were also showed non-significantly and positively for length of pod. Rest of the characters showed non-significant and negative correlation with days to maturity. Plant height indicated highly significant and positive phenotypic correlation with characters pods per plants (0.386) and seed yield (q/ha) (0.219). Plant height were also showed non-significant and negatively phenotypic correlation with characters seed yield per plant (-0.032). Rest of the characters showed non-significant and positively correlation with plant height. Branches per plant recorded highly significant and positively phenotypic correlation with characters *viz*. length of pod (0.382) and seed yield (q/ha) (0.322). Rest of the characters showed non-significant correlation with branches per plant. Pods per plant showed highly significant and positive phenotypic correlation with seed yield (q/ha) (0.503). Rest of the characters showed non-significant and negatively phenotypic correlation with pods per plant. Length of pod recorded significant and positive phenotypic correlation with characters 1000-seed weight (0.213) and non-significant and negative phenotypic correlation with seed yield per plant (-0.001). Remaining characters showed non-significant correlation with seed yield (q/ha). Seeds per pod showed highly significant and positive phenotypic correlation with characters seed yield (q/ha) (0.390) and significant and negative correlation with seed yield per plant (-0.259). 1000-seed weight showed highly significant and positive phenotypic correlation with characters seed yield (q/ha) (0.368). The seed yield or economic yield, in almost all the crops is referred as super character which results from multiplicative interaction of several other characters that are termed as the yield components. Thus, genetic balance or overall net effect produced by various yield components and information about their association with yield and also with each other is very useful for developing efficient breeding strategies for evolving high yielding varieties. In these respects, the correlation coefficient which provide symmetrical measurement of degree of association between two variable or characters help in understanding the nature and magnitude of association among yield and yield components. In the present study simple correlation coefficient are computed among ten characters in table. The genotypic correlation coefficients between different characters are generally similar in sign and nature to the corresponding phenotypic correlation coefficient in the experiment. However, genotypic correlations are higher in magnitude than the corresponding phenotypic values. In present study, a very strong positive association of seed yield were observed with pods per plant, at phenotypic as well as genotypic level. Thus, pods per plant were identified as most important associates of seed yield in fenugreek. Some of these characters have also been reported to exhibited positive correlation with seed yield by earlier workers *Singh and* Raghuvansi (1984) [11]; Dash and Kole (2000) [3]; Kole and Mishra (2006) [9]; Gangopadhyay *et al*. (2009) [8]. The days to 50% flowering showed strong positive association as phenotypic level with branches per plant, branches per plant exhibited highly significant and positive phenotypic and genotypic correlation with length of pod and seed yield (q/ha). Pods per plant had strong positive association at phenotypic level with seed yield (q/ha). seed per pod showed strong negative association as phenotypic level with seed yield per plant and also showed significant and negative correlation with seed yield (q/ha). 1000-seed weight exhibited highly significant and positive phenotypic correlation with seed yield (q/ha). All the estimates of phenotypic correlation and high order genotypic correlations between different seed yield characteristics were significant positive in nature. Seed yield also showed positive genotypic and phenotypic correlation of either significant or non-significant nature with all the characters. The results exhibited mostly positive phenotypic correlation of substantial nature between different seed yield characters under study which represented a highly favourable situation from breeding point of view. The strong positive association between seed yield characters may lead to rapid and high improvement during selection owing correlated response because improvement in on characters may bring improvement in other character.

Table 1: Direct and indirect effects of different characters on seed yield per plant at phenotypic level in Fenugreek genotypes

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches/ plant	Pods/ plant	Length of pod (cm)	Seeds/ pod	1000-seed weight (g)	Correlation with Seed yield/ plant (g)
Days to 50% flowering	0.017	0.001	0.004	0.001	0.002	0.001	0.001	0.000	0.155
Days to maturity	-0.004	-0.052	0.014	0.004	-0.004	0.002	0.015	0.003	-0.247
Plant height (cm)	0.010	-0.013	0.047	0.018	0.009	0.000	0.002	-0.002	0.219
Branches/ plant	0.004	-0.005	0.025	0.065	0.025	-0.010	0.006	-0.008	0.322
Pods/ plant	0.070	0.045	0.118	0.242	0.633	-0.062	-0.123	-0.043	0.503
Length of pod (cm)	-0.001	0.001	0.000	0.005	0.003	-0.031	-0.007	0.000	0.036
Seeds/ pod	0.053	-0.193	0.030	0.058	-0.125	0.138	0.646	-0.168	0.390
1000-seed weight (g)	0.006	-0.032	-0.018	-0.071	-0.040	-0.001	-0.152	0.585	0.368

Residual effect = 0.142

Table 2: Estimates of phenotypic correlation coefficient between different characters in Fenugreek genotypes

Character	Days to maturity	Plant height (cm)	Branches/ plant	Pods/ plant	Length of pod (cm)	Seeds/ pod	1000-seed weight (g)	Seed yield/ plant (g)	Seed yield (q per ha.)
Days to 50% flowering	1.000	0.075	0.217*	0.068	0.111	0.034	0.083	0.010	0.155
Days to maturity		1.000	-0.275**	-0.077	0.072	-0.033	-0.299**	-0.054	-0.247*
Plant height (cm)			1.000	0.386**	0.186	0.006	0.046	-0.032	0.219*
Branches/ plant				1.000	0.382**	-0.146	0.089	-0.121	0.322**
Pods/ plant					1.000	-0.099	-0.194	-0.068	0.503**
Length of pod (cm)						1.000	0.213*	-0.001	0.036
Seeds/ pod							1.000	-0.259*	0.390**
1000-seed weight (g)								1.000	0.368**
Seed yield per plant									1.000

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

The path coefficient analysis was carried out by using genotypic as well phenotypic correlation coefficient between nine characters to estimate direct and indirect effects of eight characters on seed yield per plant. The direct and indirect effects of different characters on seed yield per plant at phenotypic level are presented in Table-1. The highest positive direct effect on seed yield per plant was exerted by seeds per pod (0.646), followed by pods per plant (0.633) and 1000-seed weight (0.585). The direct effects of remaining characters are too low to be considered important. Pods per plant (0.160), followed by seeds per pod (0.138) and pods per plant (0.118) exhibited highest positive indirect effect on seed yield per plant. The rest of estimates of indirect effects obtained in path coefficient analysis at phenotypic level are negligible. The estimates of residual factor (0.412) obtained in this phenotypic path analysis are low.

Path coefficient analysis is a tool to partition the observed correlation coefficient into direct and indirect effect of independent characters on dependent character to provide clear picture of character association for formulating efficient selection strategy. Path analysis differs from simple correlation in that it point out the causes and their relative importance, whereas the latter measures simply the mutual association ignoring the causation. In the present study, the path coefficient analysis was carried out at phenotypic level. Seeds per pod, followed by Pods per plant, and 1000-seed weight exerted very high order positive direct effect on seed yield at phenotypic level. Thus, seeds per pod, pods per plant and 1000-seed weight emerged as most important direct seed yield influencing characters. These characters have also been identified as major direct contributors towards seed yield in different crops by earlier workers, Singh and Raghuvanshi (1984) [11]; Dash and Kole (2000) [3]; Datta *et al*. (2005) [5]; Dashora *et al*. (2011) [4]; Patahk *et al*. (2014) [10]. The direct effects of remaining characters were negligible phenotypic path analysis. Pods per plant (0.242), (0.118), followed by seeds per pod (0.138), and exhibited highest positive indirect effect on seed yield per plant. The rest of estimates of indirect effects obtained in path coefficient analysis at phenotypic level are negligible. Seeds per pod (0.646), followed by pods per plant (0.633) and 1000-seed weight (0.585) exerted high order positive direct effects on seed yield per plant. The direct effects of the rest characters are very low. Pods per plant (0.242), (0.118), followed by seeds per pod (0.138) exerted high order positive indirect effect on seed yield per plant. The rest of estimates of indirect effects obtained in path coefficient analysis at phenotypic level were too low to be considered incorporated.

On the basis of result of path coefficient analysis at phenotypic level it can be concluded that characters identified as important direct components like, seeds per pod, pods per plant and 1000-seed weight and important indirect components like pods per plant and seeds per pod should be given due consideration at the time of devising selection strategy for improving seed yield in fenugreek.

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. The genotypic correlation was generally similar in nature and higher in magnitude than corresponding phenotypic correlation coefficient. A very strong highly significant and positive correlation of seed yield (q/ha) at genotypic and phenotypic levels was observed with pods per plant (0.503**). Emphasis should be given to select directly these traits to increase the production and productivity of Fenugreek. Path coefficient analysis, identified that seeds per pod (0.646) and pods per plant (0.633) as major direct contributions towards seed yield (q/ha). 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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