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Studies on character association and path analysis of yield with important yield contributing traits in Fenugreek (*Trigonella foenum-graecum* L.)

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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.), correlation coefficient, path coefficient

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 (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, upgradation of the existing level (Thomas *et al.* 1989, Edison and Johny 1991 and Peter, 1996). 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 (Aykroyd, 1963), 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 *champa methi* 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 (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* above 283 kg N/ha (Gill & Singh, 1988 and Kohli, 1983).

The genetic improvement of any crop depends upon its judicious exploitation through efficient breeding methods. Aim of any plant breeding programme is to develop high yielding varieties with better quality superior over existing one. The variability for selection of superior type can be obtained through vigorous screening and evaluation of germplasm. The knowledge of association between characters and their direct and indirect contribution towards expression of yield parameters are additional help to plant breeder in deciding the selection criteria. Germplasm collections provide the richest source of variability.

Path analysis may be of limited utility to a plant breeder, but it definitely gives an insight into a complex relationship among different characters in a biological system, and provides information whether the observed correlation is due to the direct influence or through other variables. Thus, path analysis specifies the causes and also gives the relative importance of the characters. Considering the above aspects, the present investigation was under taken to estimate correlation coefficients among various yield and yield contributing traits, and to find out the direct and indirect effect of yield with other traits.

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). Estimation of Correlations coefficient were calculated by the method suggested by Searle (1961) and Path coefficient analysis were calculated by the method suggested by Dewey and Lu (1959).

Results and Discussion

Correlation coefficient was worked out at phenotypic and genotypic levels for different traits in fenugreek (*Trigonella foenum-graecum* L.) genotypes are presented in Table 1 and 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 significant and positive phenotypic correlation of days to 50% flowering was estimated with plant height (0.217**) and significant and positive phenotypic correlation was registered with 1000-seed weight (0.196*) (Shukla and Sharma 1978). Days to 50% flowering were also showed non-significant and negative phenotypic correlation with pods per plant (-0.126). Rest of the characters showed non-significant correlation with 1000-seed weight. Days to maturity exhibited non-significant and positive phenotypic correlation with characters 1000-seed weight (0.115). Rest of the characters showed non-significant correlation with days to maturity. Plant height indicated highly significant and positive phenotypic correlation with characters length of pod (0.221**) (Sharma *et al.* 1990, Chandra 1992), non-significant and positive phenotypic correlation with characters branches per plant (0.107) and seeds per pod (0.104). Rest of the characters showed non-significant correlation with plant height. Branches per plant recorded non-significant and negative phenotypic correlation with characters *viz*. seeds per pod (-0.124) and seed yield per plant (-0.119). 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 per plant (0.676**) (Sharma *et al.* 1990, Chandra 1992, Dash and Kole 2000, Chandra *et al.* 2000, Singh 2000, Gangopadhyay *et al.* 2009), highly significant and negative phenotypic correlation with seed per pod (-0.635**) and 1000-seed weight (-0.474**), while length of pod showed significant and negative phenotypic correlation (-0.163*). Rest of the characters showed non-significant correlation with pods per plant. Length of pod recorded non-significant and positive phenotypic correlation with characters 1000-seed weight (0.134) and non-significant and negative phenotypic correlation with seed yield per plant (-0.113). Remeining characters showed non-significant correlation with seed yield (q/ha). Seeds per pod showed highly significant and positive phenotypic correlation with characters 1000-seed weight (0.216**) (Singh 2000).

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 3 and 4. The highest positive direct effect on seed yield per plant was exerted by pods per plant (1.426), followed by seeds per pod (0.742) and 1000-seed weight (0.591) (Shukla and Sharma 1978, Singh and Raghuvansi 1984, Patahk *et al.* 2014). The direct effects of remaining characters are too low to be considered important. Seeds per pod (0.160), followed by 1000-seed weight (0.127), (0.116) 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 (0.142) obtained in this phenotypic path analysis are low. The direct and indirect effects of different characters on seed yield per

plant at genotypic level has been depicted Table 5. Pods per plant (1.427), followed by seeds per pod (0.692) and 1000-seed weight exerted high order positive direct effects on seed yield per plant Banerjee and Kole 2004 [7], Chandra *et al.* 2000). The direct effects of the remaining characters are very low. Seeds per pod (0.237), followed by 1000-seed weight (0.193), (0.176), (0.120) exerted high order positive indirect effect on seed yield per plant. The rest of estimates of indirect effects obtained in path coefficient analysis at genotypic level are too low to be considered incorporated. The estimates of residual factor (0.067) obtained in this genotypic path analysis are low.

Table 1: 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)
Days to 50% flowering	0.049	0.217**	0.043	-0.126	0.049	0.047	0.196*	-0.029
Days to maturity		-0.084	-0.055	-0.046	0.004	0.092	0.115	0.062
Plant height (cm)			0.107	-0.127	0.221**	0.104	-0.017	-0.132
Branches/ plant				0.001	0.042	-0.124	-0.066	-0.119
Pods/ plant					-0.163*	-0.635**	-0.474**	0.676**
Length of pod (cm)						0.057	0.134	-0.113
Seeds/ pod							0.216**	-0.040
1000-seed weight (g)								0.075

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

Table 2: Estimates of genotypic 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)
Days to 50% flowering	-0.256	0.422	-0.042	-0.255	0.125	0.056	0.311	-0.141
Days to maturity		-0.682	-0.105	0.004	0.014	0.139	-0.204	0.002
Plant height (cm)			0.152	-0.228	0.378	0.241	-0.141	-0.279
Branches/ plant				-0.048	0.018	-0.308	0.050	-0.296
Pods/ plant					-0.164	-0.651	-0.537	0.682
Length of pod (cm)						0.029	0.212	-0.110
Seeds/ pod							0.343	-0.053
1000-seed weight (g)								0.060

Table 3: 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	0.005	0.000	0.001	0.000	-0.001	0.000	0.000	0.001	-0.029
Days to maturity	0.000	-0.009	0.001	0.000	0.000	0.000	-0.001	-0.001	0.062
Plant height (cm)	-0.005	0.002	-0.022	-0.002	0.003	-0.005	-0.002	0.000	-0.132
Branches/ plant	0.001	-0.001	0.001	0.012	0.000	0.000	-0.001	-0.001	-0.119
Pods/ plant	-0.180	-0.066	-0.181	0.001	1.426	-0.233	-0.905	-0.676	0.676
Length of pod (cm)	0.000	0.000	0.001	0.000	0.000	0.003	0.000	0.000	-0.113
Seeds/ pod	0.035	0.068	0.077	-0.092	-0.471	0.042	0.742	0.160	-0.040
1000-seed weight (g)	0.116	0.068	-0.010	-0.039	-0.280	0.079	0.127	0.591	0.075

Residual effect = 0.142

Table 4: Direct and indirect effects of different characters on seed yield per plant at genotypic 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	0.028	-0.007	0.012	-0.001	-0.007	0.004	0.002	0.009	-0.141
Days to maturity	0.008	-0.030	0.020	0.003	0.000	0.000	-0.004	0.006	0.002
Plant height (cm)	-0.030	0.048	-0.071	-0.011	0.016	-0.027	-0.017	0.010	-0.279
Branches/ plant	0.001	0.004	-0.005	-0.034	0.002	-0.001	0.011	-0.002	-0.296
Pods/ plant	-0.364	0.006	-0.325	-0.068	1.427	-0.234	-0.930	-0.767	0.682
Length of pod (cm)	0.001	0.000	0.003	0.000	-0.001	0.009	0.000	0.002	-0.110
Seeds/ pod	0.039	0.096	0.167	-0.213	-0.451	0.020	0.692	0.237	-0.053
1000-seed weight (g)	0.176	-0.115	-0.080	0.028	-0.303	0.120	0.193	0.564	0.060

Residual effect = 0.067

Table 5: 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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