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Research Article

Studies on genetic variability, correlation and path coefficient analysis in fenugreek (*Trigonella foenum graecum* L.) genotypes

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Abstract
An experiment was carried out on fenugreek genotypes to study the genetic variability, and relationship among yield traits. Analysis of variance showed that the genotypes significantly differed in all the growth and yield parameters studied. The variability study indicated that PCV was higher than the GCV for all the traits and high genotypic and phenotypic coefficient of variation was recorded for the number of primary and secondary branches per plant, the number of pods per plant and seed yield per plant. High heritability was observed for all the studied characters. Correlation studies revealed that the seed yield was significantly and positively correlated both at the genotypic and phenotypic levels to pod length and the number of pods per plant. The highest positive direct effect on seed yield per plant was observed on the number of pods per plant (0.3467) followed by the number of secondary branches per plant (0.3259), the number of seeds per pod (0.2301) and pod length (0.1468). The information on these statistical parameters would be helpful to identify the genotypes having superior yield potential which can be utilized in the improvement of fenugreek.

Key words: Genotypic variability, heritability, correlation, path coefficient analysis

INTRODUCTION

Fenugreek is an important seed spice in India next to cumin and coriander and it is botanically called *Trigonella foenum graecum* L. belonging to the subfamily Papilionaceae, family Fabaceae (leguminaceae) within the order Leguminales. The genus has two important species *viz*. *Trigonella foenum graecum* L. (common methi) and *Trigonella corniculata* L. (kasuri methi) (Kumari *et al*., 2016). It is native to southern Europe and the Mediterranean region but cultivated worldwide and in India, it is popularly grown by its vernacular name methi (Acharya *et al*., 2011). Fenugreek is an annual herb, 30 to 90 cm tall, leaves are light green color which is pinnately trifoliate. The flowers are white or yellow in colour and the cleistogamous nature of the flowers favors self-pollination. It is diploid species with chromosome number 2n=16 (Upadhyay *et al*., 2020). The economic part of the plant is slender curved pods, which contain 10 to 20 numbers of small, yellowish-brown seeds, which are smooth and oblong, about 3 mm long, bitter in taste and having distinct flavor (Altuntas *et al*., 2005).

All most l parts of the crops are utilized in one or other forms. The important culinary uses of the fenugreek crop include, herb (dried or fresh leaves), spices and

condiments (seeds), vegetables (fresh leaves), and salads (germinated sprouts and micro greens). Fenugreek leaves are rich in iron, calcium, protein, vitamins and minerals. The seed contains 45-60% carbohydrate mainly mucilaginous fiber (galactomannans), protein (25.5%), fat (7.9%), saponins (0.6-1.7%), and major nutrients like phosphorus, potassium, and mineral nutrients like calcium, iron and sodium, amino acids like leucine, valine, lysine, and phenylalanine (Mehrafarin *et al*., 2011).

Being a leguminous crop, its root nodules containing Rhizobium bacterium which fixes atmospheric nitrogen by which it improves soil fertility. The significance of fenugreek has increased due to the presence of a steroid saponin called "Diosgenin" that is being used in the pharmaceutical industry for the production of sex hormones and oral contraceptives (Meena *et al*., 2017). Further, the crop attracted the attention of the farmers and agricultural scientists due to high remunerative prices.

The total area and production of fenugreek in India during 2019-2020 was 1,20,340 hectares and 1,88,480 tonnes, respectively. Rajasthan is the leading state in fenugreek production with an area of 45,310 hectares, 62,890 tonnes of production (Statistics, 2019) and hence it is called as fenugreek bowl of India. Even though India is one of the major producers of fenugreek in the world, the productivity of fenugreek is low. The productivity of the crop mainly depends on the yield and yield contributing components (Sarada *et al*., 2011). Thus, there is immense scope for crop improvement in fenugreek for yield improvement and breeding of high yielding fenugreek varieties becomes inevitable. Hence, the present study was undertaken to evaluate different genotypes of fenugreek for growth and yield traits.

MATERIALS AND METHODS

The field experiment was conducted during *Rabi* 2020-2021 on clay loam soil at the College orchard, Department of Spices and Plantation crops, Horticultural College and Research Institute, TNAU, Coimbatore. The experimental site of the orchard at HC&RI is geographically situated in the tropical plain topography at 11° N Latitude, 77° E Longitude and at an altitude of 411m above Mean Sea Level (MSL). Annual rainfall is 830 mm. The experiment was laid out in randomized block design with three replications. Each fenugreek genotype was sown in the plot size of 2x2 m^2 at the spacing of 30 x 10 cm between the rows and plants, respectively. This investigation was carried out with eighteen genotypes including two check varieties (Hisar Sonali and CO2). All the recommended packages of practices were adopted for raising a good crop. The data on days to 50 % flowering was recorded on a plot basis. Five randomly selected plants from each of the genotypes in each replication were tagged for recording the observations on plant height (cm), the number of primary branches per plant, the number of secondary branches per plant, the number of pods per plant, pod length (cm), the number of seeds per pod, seed yield per plant (g), seed yield per plot (g) and estimated yield (kg/ha). The genotypic and phenotypic co-efficients of variability were worked out as per Burton and De - Vane (1953) and heritability and genetic advance were calculated following Johnson *et al*. (1955).

Phenotypic and genotypic correlation co-efficient for seed yield was calculated as per the formula given by Al-Jibouri *et al*. (1958) while path co-efficient analysis was determined following Dewey and Lu (1959). All the calculations were performed with the help of the statistical package TNAU STAT.

RESULTS AND DISCUSSION

Eighteen genotypes of fenugreek including two check varieties were evaluated for growth and yield characters during the year 2020-2021. The mean performance for all the morphological characters (**Table 1**) showed that a high amount of variability present in the studied genotypes. Analysis of variance indicated that highly significant differences were found among the genotypes for all the characters studied. Analysis of variance was used to estimate the genetic variability parameters indicating range (minimum and maximum), mean, genotypic and phenotypic coefficients of variation, heritability and genetic advance as per cent of mean which is presented in **Table2**.

In the present investigation, a higher phenotypic coefficient of variation was obtained compared to its corresponding genotypic coefficient of variation for all the traits evaluated. But, only slight differences were noticed between these two coefficient variations for all the characters under study. It also described that genetic factors are mainly responsible for the expression of those characteristics and selection could be made effectively on the basis of phenotypic performance. These findings are in confirmation with the findings of Singh *et al*. (2015), Lodhi *et al*. (2015) and Khanpara *et al*. (2016) in fenugreek and cowpea.

The highest genotypic and phenotypic coefficient of variations were observed in the number of primary branches per plant, the number of secondary branches per plant, the number of pods per plant and seed yield per plant, respectively. However, it exhibited moderate GCV and PCV for plant height at 60 days after sowing and the number of seeds per pod, while the remaining characters such as plant height at 90 DAS, days to 50 per cent flowering and the number of seeds per pod exhibited low GCV and PCV. A lower value of GCV and PCV indicated that there is limited scope for improvement. The results are in agreement with the earlier reports of Mori *et al*. (2016), Wojo *et al*. (2016) and Verma *et al.* (2016) in fenugreek.

Table 1. Mean Performance of fenugreek genotypes for growth and yield characters

Genotypes	PH1	PH2	NPB	NSB	DFF	NOP	PL	NSP	SYP	SY/ plot	EY
TFG1	36.40	45.40	2.70	0.00	48.63	12.67	7.27	9.90	3.13	147.67	369.17
TFG2	24.93	44.23	3.60	1.23	46.67	13.43	8.67	11.30	2.57	161.67	404.17
TFG3	46.93	55.03	6.60	4.90	44.37	29.67	11.50	13.47	7.20	428.00	1070.00
TFG4	40.40	46.63	4.77	1.33	43.70	18.73	9.63	12.17	4.37	417.00	1042.50
TFG5	42.73	50.77	5.53	1.13	41.33	24.53	9.33	12.03	2.20	254.00	635.00
TFG6	47.90	54.57	4.43	1.07	46.00	19.10	10.83	10.80	3.83	157.33	393.33
TFG7	41.67	46.40	3.60	2.07	44.70	22.63	9.27	11.40	3.13	217.33	543.33
TFG8	42.60	48.63	5.60	0.53	45.67	21.67	10.00	10.43	4.07	231.33	578.33
TFG9	41.50	47.83	5.00	2.10	47.20	22.43	9.47	10.63	5.33	205.67	514.17
TFG10	42.67	49.30	4.70	2.30	42.67	24.30	9.90	10.07	3.37	253.00	632.50
TFG11	38.60	44.13	4.73	0.33	47.73	15.63	9.13	10.83	2.17	188.33	470.83
TFG12	41.00	48.53	4.60	0.60	46.33	18.47	9.43	10.37	4.13	367.00	917.50
TFG13	45.77	50.63	6.03	3.27	47.43	26.23	11.17	12.60	6.93	343.67	859.17
TFG14	33.60	41.93	3.20	1.53	44.67	19.17	9.20	11.60	4.27	320.33	800.83
TFG15	42.93	47.63	5.20	0.87	45.33	14.10	8.23	12.00	3.27	265.67	664.17
TFG16	34.20	43.37	4.13	1.33	46.50	14.63	8.43	10.50	3.30	123.33	308.33
NC	41.73	48.73	5.20	1.13	44.63	19.03	10.53	10.93	3.80	323.33	808.33
CO-2	41.73	43.73	4.70	2.47	46.20	18.73	10.10	10.53	3.73	274.00	685.00

(PH1- Plant height at 60 DAS (cm), PH2- plant height at 90 DAS (cm), NPB- Number of primary branches per plant, NSB- Number of secondary branches per plant, DFF- Days to 50 per cent flowering, NOP- Number of pods per plant, PL- Pod length(cm), NSP- Number of seeds per pod, SYP- Seed yield per plant (g), SY- Seed yield per plot (g), EY- Estimated yield (kg)/ha)

Table 2. Genotypic and phenotypic coefficient of variation, heritability and genetic advance as per cent of mean of fenugreek genotypes

Characters	Mean	Range		Phenotypic coefficient of variation (%)	Genotypic coefficient of variation (%)	Heritability (%)	Genetic Advance	Genetic advance as % mean
		Maximum	Minimum					
Plant height at 60 DAS (cm)	40.41	47.9	24.90	13.50	13.37	98.04	11.01	27.27
Plant height at 90 DAS (cm)	47.64	55.03	41.93	7.71	7.59	96.83	7.33	15.38
Number of Primary branches per plant	4.69	6.60	2.70	21.19	20.99	98.08	2.00	42.83
Number of Secondary branches per plant	1.57	4.90	0.00	20.32	21.18	96.98	2.35	43.49
Days to 50 per cent flowering	45.54	48.63	41.33	4.22	3.92	86.60	3.43	7.53
Number of pods per plant	19.73	29.67	12.67	23.87	23.68	98.42	9.55	48.40
Pod length (cm)	9.56	11.50	7.27	11.17	11.03	97.44	2.14	22.43
Number of seeds per pod	11.20	13.47	9.90	8.60	8.46	96.82	1.92	17.16
Seed yield per plant (g)	3.93	7.20	2.17	35.22	35.11	99.34	2.83	72.09

The estimation of heritability along with genetic advance can be utilized for predicting the resultant effect of selection on phenotypic expression. High heritability was found for all the studied characters. The high value of heritability for all the characters indicated that all the studied traits were less influenced by the environment, so the phenotypes were the reliable representatives of their genotype and thus as they are less influenced by the environment indicating the reliability of selection based on these traits would be effective. Similar results were reported by Wojo *et al*. (2016) in fenugreek.

Genetic advance is the genetic improvement of the offspring through selection over the original population and it helps to evaluate the selection procedures. The value of genetic advance exhibited high fluctuation due to the masking effect of environment upon characters. Therefore, to attain relative comparison of the characters in relation to the environment, genetic advance as per cent mean was calculated to predict the genetic gain (**Table 2**), and were classified as high (above 20%), medium (10%-20%) and low (below 10%).

High heritability coupled with high genetic advance was observed for characters viz., plant height, the number of primary branches per plant, the number of secondary branches per plant, the number of pods per plant, pod length and seed yield per plant. The results indicate that these characters are governed by additive gene actions and these traits showed higher responses for selection. The findings are in accordance with the reports of Gurjar *et al*. (2016) and Singh *et al*. (2012) for the number of pods per plant and seed yield per plant in fenugreek. High heritability along with moderate genetic advances as percent of mean was manifested by plant height at 90 DAS, the number of seeds per pod. The similar result was reported in fenugreek by, Dashora *et al*. (2011) and Abhishek *et al.* (2009) for plant height and number of seeds per pod.

High heritability along with low genetic advance was observed for days to 50 per cent flowering. It may be assumed that this trait is governed by non-additive gene action. The heritability is being exhibited due to the favourable influence of the environment rather than the genotype and simple selection will not be satisfying. Though this can be improved by the development of hybrid or utilization of transgressive segregants in heterosis breeding programmes.

Genotypic and phenotypic correlation among different traits revealed (**Table 3**) that seed yield per plant had highly significant and positive genotypic correlation on pod length, the number of pods per plant, the number of seeds per pod and the number of primary and secondary branches per plant, whereas a significant positive correlation was observed for plant height. On the other side, days to 50 per cent flowering had non-significant positive correlation with seed yield and these reports are in agreement with the findings of Jain *et al.* (2013), Prajapati *et al.* (2011) and Choudhary *et al.* (2013) in fennel and fenugreek.

Path coefficient analysis was carried out for different characters using genotypic and phenotypic correlation coefficients and taking seed yield per plant as dependable variable in order to see the causal factor and also to identify the components which are responsible for

Table 3. Genotypic and phenotypic correlation coefficients between different characters of fenugreek genotypes

Variables	PH1	PH2	NPB	NSB	DFF	NOP	PL	NSP	SYP
PH1	**1**	0.754**	0.662**	0.371**	-0.253	0.640**	0.638**	0.255	0.461**
PH2	0.754**	**1**	0.652**	0.411**	-0.280*	0.641**	0.658**	0.377**	0.475**
NPB	0.662**	0.652**	**1**	0.507**	-0.294*	0.664**	0.693**	0.534**	0.545**
NSB	0.371**	0.411**	0.507**	**1**	-0.211	0.752**	0.653**	0.603**	0.507**
DFF	-0.251	-0.281*	-0.294*	-0.215	**1**	-0.465**	-0.254	-0.333*	0.101
NOP	0.640**	0.641**	0.664**	0.752**	-0.465**	**1**	0.760**	0.495**	0.638**
PL	0.638**	0.658**	0.693**	0.653**	-0.254*	0.760**	**1**	0.419**	0.646**
NSP	0.255	0.377**	0.534**	0.603**	-0.333*	0.495**	0.419**	**1**	0.523**
SYP	0.461**	0.475**	0.545**	0.507**	0.101	0.638**	0.646**	0.523**	**1**

(Upper diagonal values indicate phenotypic correlation and lower diagonal values indicate genotypic correlation. *0.001 significance and ** 0.005 significance)

(PH1- Plant height at 60 DAS , PH2- plant height at 90 DAS , NPB- Number of primary branches per plant, NSB- Number of secondary branches per plant, DFF- Days to 50 per cent flowering, NOP- Number of pods per plant, PL- Pod length , NSP- Number of seeds per pod, SYP- Seed yield per plant.

Table 4. Direct (bold) and indirect effect of characters on seed yield per plant of fenugreek

Characters	PH1	PH2	NPB	NSB	DFF	NOP	PL	NSP	SYP
PH1	**0.0643**	0.0341	-0.0046	0.1227	-0.1305	0.2248	0.0962	0.0605	0.4674
PH2	0.0501	**0.0438**	-0.0046	0.137	-0.1591	0.2295	0.0993	0.0909	0.4869
NPB	0.0434	0.0294	**-0.0068**	0.172	-0.1495	0.2332	0.1046	0.1237	0.5500
NSB	0.0242	0.0184	-0.0036	**0.3259**	-0.1153	0.2657	0.0989	0.1434	0.5076
DFF	-0.0168	-0.0139	0.002	-0.075	**-0.5006**	-0.1718	-0.0402	-0.0796	0.1053
NOP	0.0417	0.029	-0.0046	0.2498	-0.248	**0.3467**	0.1137	0.1161	0.6443
PL	0.0421	0.0296	-0.0048	0.2195	-0.1372	0.2686	**0.1468**	0.1005	0.6652
NSP	0.0169	0.0173	-0.0036	0.2032	-0.1732	0.1749	0.0641	**0.2301**	0.5297

Residual effect = 0.4581

PH1- Plant height at 60 DAS , PH2- plant height at 90 DAS , NPB- Number of primary branches per plant, NSB- Number of secondary branches per plant, DFF- Days to 50 percent flowering, NOP- Number of pods per plant, PL- Pod length , NSP- Number of seeds per pod, SYP- Seed yield per plant.

producing maximum seed yield per plant. Path analysis showed a high to moderate/low direct effect of the studied ancillary traits on dependent traits *i.e*., seed yield per plant (**Table 4**). The highest direct effect on seed yield was shown by the number of pods per plant (0.3467) followed by the number of secondary branches per plant (0.3259), the number of seeds per pod (0.2301), pod length (0.1468), plant height at 60 DAS (0.0643) and plant height at 90 DAS (0.0438) while the number of primary branches per plant (**-**0.0068) and days to 50 per cent flowering (-0.5006) had a negative direct effect on seed yield per plant. Thus, the path coefficient analysis revealed that the number of pods per plant, the number of secondary branches per plant, the number of seeds per pod, pod length are the most important characters for selection and selection based on these traits would be more rewarding for improvement of fenugreek (**Table 4**) as evidenced by Balai *et al.* (2006) and Fikreselassie *et al.* (2012) in fenugreek.

Based on the results of the present investigation, it is concluded that a wide range of variability is found among the genotypes for all the characters representing that considerable scope is existing for the improvement of fenugreek genotypes through selection. Genetic parameters in association with genetic variability, correlation and path analysis study indicated that for selection of superior genotypes primary importance should be given on the number of pods per plant, the number of seeds per pod, the number of primary and secondary branches per plant and pod length.

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