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Variability, Correlation and Path Coefficient Analysis in Fenugreek (*Trigonella foenum-graecum*) Genotypes

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ABSTRACT

Background: Fenugreek (*Trigonella foenum-graecum*) is an important leguminous seed spice and belongs to the family Fabaceae.Both seed and leaves of fenugreek are widely used as a cooking spice to enhance the taste of many meat, poultry and vegetable dishes. Utilization of variability is essential for selection of best genotypes. With this background, present experiment was conducted to estimate genetic variability, correlation and path coefficients for yield and other yield attributing traits to select the promising genotypes for high yield in fenugreek.

Methods: The experiment on assessment of variability, correlation and path coefficient in Fenugreek genotypes for growth and yield attributes was carried out at the College Orchard, Tamil Nadu Agricultural University, Coimbatore. Sixteen fenugreek genotypes, sourced from various locations, were sown in a randomized block design with two replications during winter season of 2021-22 and 2022-23. Observations on growth and yield parameters were recorded and analysed for variance, variability, correlation and path coefficients.

Result: CultivarTFG.12 recorded significantly highest values plant height (48.76 cm), number of grains per pod (11.25), 1000-grain weight (11.18 g), grain yield per plant (6.39 g) and estimated yield per hectare (440 kg) with least number of days taken to flowering (34.50 days). In this study, analysis of variance revealed the presence of considerable amount of variability. Moderate to high genotypic and phenotypic coefficient of variation was observed for characters like grain yield per plant and length of pods, number of grains per pod. High heritability coupled with genetic advance as per cent of mean were observed for characters like number of productive branches, number of pods per plant, length of pod, number of grains per pod and grain yield per plant. The genotypic and phenotypic correlation studies revealed the grain yield recorded significant and positive correlation with 1000-grain weight and number of grains per pod number of branches per plant, number of grains per pod and 1000 grain weight exerted the highest positive direct effect on grain yield per plant.

Key words: Correlation, Fenugreek, Genetic advance, Heritability, Path analysis, Variability, Yield.

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum*) is an important leguminous seed spice crop. Fenugreek is an annual plant valued for its significant medicinal properties (Gupta *et al*., 2013). The cultivated fenugreek or common methi originated in the Mediterranean region and spread to various parts of the world, from Greece to Russia, China and India. Two cultivated species of genus *viz.Trigonella foenum-graecum* (commonly known as fenugreek) and *Trigonella corniculata* (commonly known as pan methi or methi) are commercially cultivated seed spices in tropical as well as temperate regions of India (Meena *et al.,* 2021). The tender leaves and stem are consumed as curried vegetable and also as a fodder crop before flowering. The leaves contain seven kinds of saponins, which are known as graecunins. These compounds are glycosides of diosgenin. Leaves contain 86.1% moisture, 4.4% protein, 0.9% fat,1.5% minerals (calcium, iron, phosphorous), 1.1% fibre and 6% carbohydrates and traces of vitamins *viz.,*carotene, thiamine, riboflavin, niacin and vitamin C (Brar *et al.,* 2013). Both grains and leaves of fenugreek are widely used as a culinary spice to enhance the taste of many meat, poultry and vegetable dishes (Thomas *et al.,* 2011). The fresh or dried leaves are used to flavour dishes in many parts of India. In Egypt and Asia sprouts of fenugreek and young leaves are eaten as green vegetables. Fenugreek grain is a natural source of galactomannan gum. This property of fenugreek grain has provided the food industry with an opportunity to use grain extracts as thickening agent in foods or as food emulsifier (Dhull *et al.,* 2023). The area and production of fenugreek in India during

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2023-24 was 1,45,366 ha and 2,28,649 t respectively. Productivity of fenugreek is low in India.The productivity of crop mainly depends on yield and yield contributing characters.

High heritability and high genetic advance are important for the improvement of any character Kumar *et al.* (2020). Heritability estimates in broad sense when used in conjunction with the genetic advance would give better information than the heritability alone. This study helps to identify the superior genotypes and further utilization of these genotypes in breeding programme. The yield is determined by number of characters and consequently help to select suitable genotype. Study by Gurjar *et al*. (2016) revealed that fenugreek yield improvement is achievable through selection for traits including dry weight at flowering, protein content, biological yield, seeds per pod and 1000-seed weight, which showed high variability, heritability and positive correlation with seed yield. According to a study by Shekawat *et al*. (2023) the significant genotypic and phenotypic coefficient of variation, along with high heritability and substantial genetic gain in traits such as the number of branches per plant, number of pods per plant, test weight and seed yield per plant, indicate that these characteristics can be valuable selection criteria for identifying superior parental lines in fenugreek breeding programs.

The level of association among the growth and yield attributes can be determined by correlation analysis The crop yield is always relies on the action and interaction of important growth and yield characters (Tiwari *et al*., 2024). Identification of high yielding adaptable varieties and proper plant geometry are the first and prime cultural operation to augment productivity of fenugreek (Sharanya *et al*., 2018). Genotypic correlation coefficients give a measure of genetic association between characters to identify the important characters (Gerring *et al.,* 2022). Phenotypic correlations do not always indicate genetic causation but may in fact be due to the underlying population structure (Li *et al.,* 2021). With this background, studies on variability, correlation and path coefficient studies in Fenugreek genotypes was carried out to screen the superior genotypes for further improvement.

MATERIALS AND METHODS

The present experiment was conducted at College Orchard of Tamil Nadu Agricultural University, Coimbatore during winter season of 2021-22 and 2022-23.The experiment was conducted in randomized block design and replictaed thrice. The treatments consisted of 16 cultivars of fenugreek collected from different sources. The crop was sown on raised beds at spacing of 20 cm × 15 cm using seed rate of 40 g/bed. Data from five plants of each genotype were averaged replication wise and mean data was used for statistical analysis. Observations on growth parameters *viz*., plant height, number of branches per plant, number of productive branches per plant, days taken to first flowering and days taken to 50 per cent flowering were recorded. The yield attributes *viz*., number of pods per plant, pod length, number of grains per pod, one thousand grain weight and grain yield per plant were recorded. Analysis of variance was carried out by the procedure recommended by Panse and Sukhatme (1967).

Pooled analysis was carried out by combining two winter seasons data for all the 11 characters studied. Mean, genotypic coefficients of variation (GCV) and

Table 1: Mean performance of fenugreek genotypes on growth characters.

Genotypes	Plant height (cm)	Number of branches per plant	Number of productive branches per plant	Days taken for first flowering	Days taken for 50% flowering
TFG.1	36.13	3.06	5.08	40.00	31.46
TFG.2	39.44	2.45	4.59	37.50	32.90
TFG.3	35.51	1.75	4.56	40.00	32.44
TFG.4	40.01	2.45	5.05	41.50	32.95
TFG.5	43.13	3.10	4.60	38.00	31.20
TFG.6	41.29	3.43	4.44	36.50	32.62
TFG.7	33.55	3.13	3.36	38.50	31.49
TFG.8	31.21	2.71	3.72	36.50	30.99
TFG.9	38.69	3.44	4.33	34.50	33.07
TFG.10	46.78	2.77	3.99	38.50	34.36
TFG.11	48.45	3.11	3.81	36.50	32.80
TFG.12	48.76	3.44	3.92	34.50	31.98
TFG.13	39.42	3.08	3.36	35.00	30.59
TFG.14	36.44	2.07	4.44	38.50	31.89
Hisar Sonali	39.29	2.47	4.55	35.50	31.26
CO.2	40.30	3.11	5.88	35.50	31.81
Grand mean	39.90	2.85	4.35	32.62	31.11
SE (d)	0.35	0.03	0.45	0.83	0.38
CD (5%)	0.69	0.07	0.91	1.68	0.76

phenotypic coefficients of variation (PCV) were calculated by following Burton (1952); heritability in broad sense (h^2bs) was calculated by following Burton and De Vane (1953) genetic advance (GA) and genetic advance as per cent of mean were estimated by following Johnson *et al*. (1955); correlation coefficient analysis was carried out by following Al Jibouri *et al*. (1958) path coefficient analysis was carried out by following Dewey and Lu (1959); Lenka and Misra (1973). To quantify the degree of character associated with yield and yield attributes correlation coefficient was generated. Path coefficient is a standardized partial regression coefficient and as such measures the direct influence of one trait upon another and permits the separation of correlation coefficient into component of direct and indirect effect. Pooled season data was used for statistical analysis.

RESULTS AND DISCUSSION

Per se performance of genotypes

A persual of data presented in Table 1 and Table 2 revealed that all sixteen fenugreek genotypes resulted in significant differences in various growth and yield parameters (Table 1 and Table 2). Cultivar TFG.12 recorded significant results for growth parameters *viz.,* plant height (48.76 cm), number of branches per plant (3.44) and less number of days taken for first flowering (34.50) and 50% flowering (31.98). TGF.12 recorded highest grain yield per plant (6.39 g) while genotype TFG.10 recorded significantly lowest (0.90 g) grain yield/ plant. Similarly, the number of grains per pod ranged from 8.66 (TFG.10) to 11.25 (TFG.12). These results align with findings of Meena *et al*. (2021). Similar findings were observed in a study by Yaldiz and Camlica (2021) where PI

Table 2: Mean Performance of fenugreek genotypes for yield characters.

Genotypes	Length of pod (cm)	Number of pods per plant	Number of grains per pod	Weight of 1000 grains (g)	Grain yield per plant	Estimated grain yield (t/ha)
TFG.1	9.17	23.68	11.18	9.33	1.11	0.33
TFG.2	9.72	24.14	9.63	9.26	2.00	0.30
TFG.3	9.49	23.92	10.27	10.27	2.63	0.35
TFG.4	8.76	29.31	9.27	9.27	2.03	0.33
TFG.5	8.99	38.55	9.16	9.16	3.01	0.35
TFG.6	9.23	31.76	9.40	9.40	1.99	0.38
TFG.7	10.66	22.28	8.90	8.90	2.44	0.37
TFG.8	8.71	27.65	9.67	9.67	3.38	0.39
TFG.9	8.56	23.40	9.14	9.14	2.35	0.32
TFG.10	8.93	28.32	8.77	8.77	0.90	0.38
TFG.11	8.48	26.67	8.66	8.66	2.07	0.42
TFG.12	9.66	31.92	11.25	11.18	6.39	0.44
TFG.13	9.25	30.17	9.78	9.78	2.15	0.36
TFG.14	9.16	28.46	10.21	10.21	2.30	0.38
Hisar Sonali	8.91	22.52	10.45	10.45	3.55	0,44
CO.2	11.05	20.64	9.00	9.00	3.17	0.43
Grand mean	9.30	27.08	9.67	9.52	2.59	0.33
SE (d)	0.18	1.81	0.23	0.23	0.05	0.004
CD (5%)	0.35	3.64	0.46	0.46	0.11	0.008

Table 3: Genotypic and phenotypic coefficient of variation, heritability and genetic advance as per cent of mean for fenugreek genotypes.

Characters	GV	PV	GCV	PCV	Heritability	GA as % of mean
Plant height	17.17	28.54	10.77	13.89	60.16	17.22
Number of branches	0.76	1.48	12.10	16.87	51.45	17.88
Number of productive branches	2.90	4.11	43.86	52.19	70.63	75.95
Days to first flowering	2.51	5.74	4.14	6.26	43.70	5.64
Days to fifty per cent flowering	2.94	4.33	5.21	6.32	68.00	8.85
Number of pods per plant	17.62	24.76	15.66	18.56	71.17	27.22
Length of the pod	4.17	4.90	22.12	23.97	85.12	42.04
Number of grains per pod	3.79	6.54	16.27	21.37	57.99	25.53
Thousand grain weight	0.33	0.33	6.52	6.58	98.34	13.34
Grain yield per plant	1.47	1.44	50.93	51.10	99.33	88.28

Table 4: Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficient of variation between different characters of fenugreek genotypes.

Characters	Plant height	Number of branches	Number of productive branches	Days to first flowering	Days to fifty per cent flowering	Number of pods per plant	Length of the pod	Number of grains per pod	Thousand grain weight	Grain yield per plant
Plant height	1	-0.798**	0.136	-0.517*	0.583*	0.089	0.448*	0.44	0.313	0.093
Number of branches	-0.294	1	-0.011	1.084**	-0.857**	-0.162	-0.717**	-0.6	-0.354	-0.268
Number of productive branches	-0.354	0.742**	1	-0.409	0.159	-0.241	0.011	-0.715**	-0.151	-0.262
Days to first flowering	-0.333	0.441	0.385	1	0.481*	0.122	-0.621**	-0.452**	-0.34	-0.308
Days to fifty per cent flowering	0.54	-0.559*	-0.835**	-0.306	1	0.206	0.925**	0.685**	0.057	0.197
Number of pods per plant	0.072	-0.221	0.049	0.097	0.077	1	-0.19	-0.044	0.091	0.168
Length of the pod	0.322	-0.544	-0.821**	-0.352	0.814**	-0.168	1	0.762**	0.132	0.313
Number of grains per pod	0.44	-0.6**	-0.715**	-0.452**	0.685**	-0.044	0.762**	1	0.319	0.403**
Thousand grain weight	0.313	-0.354	-0.151	-0.34	0.057	0.091	0.132	0.319	1	0.605**
Grain yield per plant	0.093	-0.268	-0.262	-0.308	0.197	0.168	0.313	0.403	0.605**	1

*significance at 5% level; **significance at 1% level.

568215 as a potential genotype for high seed yield and PI 577712 for superior protein content.

Variability parameters

A wide range of variability was found among cultivars of fenugreek, with PCV is higher than GCV for all characters, showing environmental interaction. The narrow gap between PCV and GCV indicates low environmental influence. Moderate to high GCV was observed in characters like grain yield per plant, length of pods, number of grains per pod followed by number of pods, number of branches and plant height. Similar findings were reported by Tiwari *et al.* (2024) and Krishnaveni *et al.* (2021). Low level of GCV was recorded for days taken to first flowering followed by days taken to 50 per cent flowering and 1000 grain weight. The present findings are in agreement with Krishnaveni *et al*. (2021); Meena *et al.* (2021) in fenugreek. High PCV recorded with grain yield per plant followed by length of pod, number of branches and number of grains per pod. Moderate PCV was recorded with characters *viz.,*number of pods per plant followed by number of productive branches per plant and plant height. Low PCV was recorded by the days taken to first flowering followed by days taken to 50 per cent flowering and 1000-grain weight. These reports are in agreement with the findings of Mori *et al.* (2016); Mori *et al*. (2015); Verma *et al.* (2016); Verma *et al*. (2015) and Krishnaveni *et al*. (2021) in fenugreek.

Heritability and genetic advance

High levels of heritability values for number of productive branches per plant, number of pods per plant, length of pod and grain yield per plant along with high genetic gain (Table 3) indicate additive gene effects. These findings are in agreement with Meena *et al.* (2021); Singh *et al.* (2012) for number of pods per plant, grain yield per plant and number of pods per plant. The trait 1000-grain weight recorded high heritability with moderately low genetic gain revealing both additive and non-additive genetic effects and depicting suitability for the selection in breeding programme. This is in conformity with the results of Prakash *et al*. (2020). Moderate heritability values recorded for days taken to first flowering coupled with low genetic advance as per cent of mean. These results indicated that this trait was controlled by additive or non-additive gene action, which was present in the parental genotype (Anshul Mishra and Dave, 2021). Days taken to 50% flowering recorded high heritability with low GA. These results are in accordance with findings Maurya *et al.* (2021) and Meena *et al*. (2021). Results from Singh *et al*. (2020) revealed significant genetic variability across fenugreek genotypes for most biometrical traits with high GCV and PCV values for yield components. Moderate to high heritability combined with substantial genetic advance was observed for economically important traits.

Genotypic and Phenotypic correlation coefficients with grain yield

The genotypic and phenotypic correlation among the yield components in fenugreek were presented in Table 4. The genotypic and phenotypic correlation coefficient

Table 5: Estimation of path coefficient analysis.

Variables	Plant height	Number of branches	Number of productive branches	Days to first flowering	Days to fifty per cent flowering	Number of pods per plant	Length of the pod	Number of grains per pod	1000-grain weight
Plant height	0.0260	-1.616	2.3406	-0.1509	-1.2333	0.0293	-0.3217	0.6891	0.3497
Number of branches	-0.0191	2.1972	-4.2998	0.4174	1.9355	-0.089	0.5514	-0.7160	-0.3773
Number of productive branches	-0.0138	2.1429	-4.4087	0.3176	2.1048	-0.0280	0.6479	-0.9397	-0.1406
Days to first flowering	-0.0100	2.3526	-3.5921	0.3898	1.2408	0.03835	0.4106	-0.8697	-0.4136
Days to fifty per cent flowering	0.0147	-1.9485	4.2517	-0.2216	-2.1825	0.0180	-0.7059	0.9553	0.0548
Number of pods per plant	0.0014	-0.3707	0.2324	0.0281	-0.0742	0.5315	0.0996	-0.3156	0.0655
Length of the pod	0.0125	-1.8194	4.2895	-0.2403	-2.3136	-0.0795	-0.6659	1.0383	0.1202
Number of grains per pod	0.0191	-1.6747	4.4101	-0.3609	-2.2193	-0.1786	-0.7360	0.9394	0.3390
Thousand grain weight	-0.0106	-0.9722	0.7270	-0.1891	-0.1402	0.0408	-0.0938	0.3735	0.8527

Residual effect: 0.5153.

estimates were significant and positive with 1000grain weight and number of grains per pod. Non-significant and positive correlation was recorded for plant height, days taken to 50 per cent flowering, number of pods per plant and length of pod. Non-significant and negative correlation was recorded for number of branches per plant, number of productive branches per plant and days taken to first flowering. Similar findings were recorded by Arif *et al*. (2014) in coriander. The characters *viz.,*1000 grain weight, number of grains per pod and number of pods effect the grain yield per plant. The association among the component characters suggest the scope for simultaneous improvement of this traits with a balanced approach to effect the yield. These results align with the findings of Singh and Singh (2022), where the genotypic and phenotypic correlations were exhibited significantly positive for number of pods per plant (0.765, 0.725 and 0.670, 0.651), number of seeds per pod (0.705, 0.650 and 0.666, 0.640) and pod length (0.376, 0.348 and 0.351, 0.327) with seed yield per plant in both the normal and limited irrigation conditions.

Path coefficient analysis

The estimate of residual effect reflects the adequacy and appropriateness of the characters chosen for path analysis (Table 5). The residual effect was 0.513 indicating the adequacy of characters chosen for the study. The results of the path coefficient analysis indicated the direct and indirect effects of nine contributing traits on grain yield. The traits *viz.,* number of branches per plant, number of grains per pod and thousand grain weight recorded highest positive direct effect. One thousand grain weight showed positive indirect effect on grain yield through plant height, number of productive branches per plant, number of pods per plant and number of grains per pod. Similar results were reported by Krishnaveni *et al*. (2021).

CONCLUSION

Among the sixteen fenugreek cultivars evaluated, cultivar TFG.12 recorded highest plant height (48.76 cm), number of grains per pod (11.25), 1000-grain weight (11.18 g), grain yield per plant (6.39 g) and estimated yield per hectare (440 kg) with earliest flowering (34.50 days). High heritability coupled with substantial genetic advance was noted for productive branches, pods per plant, pod length, grains per pod and grain yield per plant. Grain yield has a positive correlation between 1000 grain weight and grains per pod, suggesting that these traits significantly contribute to yield improvement.

Conflict of interest

The authors here by declare that there are no conflicts of interest.

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