INDIAN JOURNAL OF
ARID HORTICULTURE
2018, Vol. 13 (1-2):98-102

Genetic variability, heritability, correlation and path analysis in fenugreek (*Trigonella foenum graecum* L.)

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(Received : 19.09.2018, Accepted : 10.10.2018)

Abstract

Thirty fenugreek genotypes (*Trigonella foenum graecum* L) were evaluated during *rabi* season of 2012-13 to explore its existing gene pool and identify the selection indices with an eye on a more comprehensive breeding programme. Characters like number of pods per plant, protein content in seed, days to 50% flowering and dry weight at flower initiation were found to have least variation among the coefficients both at phenotypic and genotypic level. Broad sense heritability estimates were high for protein content in seed (96.9), followed by number of pods per plant (96.7). The highest genetic advance as percentage of mean was recorded for dry matter content and dry weight at flower initiation indicating that these characters are governed by additive gene action. Correlation coefficients at phenotypic and genotypic level envisaged that biological yield was having significant and positive correlation with chlorophyll content of the leaves, number of pods per plant, straw yield per plant, 1000 seed weight, dry matter content of the plant as whole and seed yield per plant while negatively correlated with the harvest index. Path coefficient analysis revealed that biological yield per plant, harvest index, dry weight at flower initiation, chlorophyll content in leaves, number of branches per plant and 1000 seed weight were the most important characters contributing towards seed yield and hence purposeful and balanced selection based on these traits would be more rewarding for improvement of fenugreek.

Key words: Genetic variability, heritability, correlation, path coefficient analysis.

Introduction

Fenugreek (*Trigonella foenum graecum* L.), popularly known as "Methi" is an important seed spice crop largely grown in India during Rabi season. Rajasthan and Gujarat are the major fenugreek producing states followed by Madhya Pradesh in which Malwa plateau contributes a major share. In Madhya Pradesh, fenugreek growing districts are Jabalpur, Chhatarpur, Indore, Mandsaur, Neemuch, Ratlam and Shajapur.The genus *Trigonella* has two species, viz. *T. foenum-graecum* and *T. corniculata*. *Trigonella foenum-graecum* plants are semi-erect, tall, moderately branched with bold, typically yellow grains. fenugreek seeds are used as condiments and flavouring food preparations. They are aromatic, carminative, tonic and galactagogue. Externally they are used in poultices for boils, abscesses, ulcers and internally as emollient for inflammation of intestinal tract. The seeds contain important steroid 'diosgenin' which is used in preparation of contraceptives. Very little effort has been made in collection maintenance and utilization of different genotypes for the improvement of this crop. There is need to assess and improve the existing genotypes and introduce cultivars for seed purpose. Study of variability is a prerequisite for improvement of yield in any crop. The performance of locally available cultivars of fenugreek is poor in the Malwa region of Madhya Pradesh. Hence, an urgent need was felt for genetic improvement to develop high yielding cultivars suitable for such situations. Improvement of yield in any crop. The performance of locally available cultivars of fenugreek is poor in the Malwa region of Madhya Pradesh. Hence, an urgent need was felt for genetic improvement to develop high yielding cultivars suitable for such situations.

Materials and Methods

The experimental material comprising of thirty divergent genotypes were sown during Rabi season of 2012-13 under randomized block design with three replications at Horticulture Research Farm, College of Horticulture, Mandsaur (M.P.), India, situated in Malwa plateau in Western part of Madhya Pradesh at North latitude of 23.450 to 24.130 and 74.440 to 75.180 East longitudes at an altitude of 435.02 meters above mean sea level. This region falls under agro climatic zone No.10 of the state. Row to row and plant to plant spacing were maintained at 40 cm and 20cm respectively. Requisite agronomic package of practices were adapted to raise a healthy crop. In each replication, five plants were randomly selected and tagged for observation. Observations were recorded for ten characters, viz. days taken to 50% flowering, plant height (cm) at 90 DAS (Days after sowing), number of branches per plant at 90 DAS, dry weight per plant at initiation of flowering, number of branches per plant, days to 50 % flowering, umbel/plant, umbellets /umbel, seeds/umbel, number of pods per plant, number of seeds per

pod,1000 seed weight (g), biological yield (g), seed yield per plant(g), dry matter content (g), length of pods (cm), harvest index, straw yield per plant (g), protein content in seed (%),oil content in seeds (%), chlorophyll content in leaves (%) and seed yield per plant. The recorded data were subjected to statistical analysis as suggested by Panse and Sukhatme (1985). The genotypic and phenotypic coefficient of variance was calculated as per the formula suggested by Burton (1952), Heritability and genetic advance as per Hanson *et.al* (1956) and Johnson *et al*. (1955) correlation coefficient.

Results and Discussion

The analysis of variance (Table 1) revealed that significant variability was present in the germplasm for all the characters studied. Estimates of genotypic (GCV) and phenotypic (PCV) variances indicated that in general, the phenotypic variances were higher than the corresponding genotypic coefficient of variations, indicating the masking influence of environmental factors in expression of these traits. Wide variability occurred in dry weight at flower initiation (PCV22.56, GCV21.36) followed by straw yield per plant (PCV21.63, GCV18.23), dry matter content (PCV19.06, GCV17.09), biological yield per plant (PCV17.97, GCV15.89), This indicates the presence of sufficient amount of genetic variability for these traits and can be exploited through breeding procedure for the improvement of these characters. This is in accordance with the findings of Sharma and Shastry (2008). The difference between the value of PCV and GCV was narrow for dry matter content, number of seeds per pod, 1000 seed weight and plant height, which indicates that phenotype was truly corresponding to its genotype for these characters. Characters like number of pods per plant, protein content in seed, days to 50% flowering and dry weight at flower initiation were found to be consistent in its behavior, both at phenotypic and genotypic level and having lowest coefficient of variation. It suggests that these traits were least influenced by the non genetic factors and were hence quite stable. This is in accordance with the findings of Banerjee and Kole (2004) and Naik (2012). Heritability estimates in broad sense were classified into three groups.high > 70, medium 50 - 70, and low < 50. In the present investigation broad sense heritability estimates were high for, protein content in seed (96.9), followed by number of pods per plant (96.7), dry weight at flower initiation (89.7) and chlorophyll content in leaves(87.10), Similar findings were reported by Meena *et al.* (2011) and Naik (2012). The genetic advance is more useful than heritability alone in predicting the resultant effect on selecting the best individuals. In the present investigation, expected genetic advance was recorded high with dry matter content (17.83), followed by number of pods per plant (17.39), biological yield (10.75) and plant height (10.50).This is in accordance with the findings of Prajapati *et al*. (2010) and Naik (2012). Heritability estimates along with the genetic advance are more useful than heritability alone in predicting the resultant effect on selecting best individuals. In the present investigation, expected genetic advance expressed as percentage of mean was high for straw yield per plant (31.66%), followed by dry matter content (31.56%), protein content in seed (30.88%), biological yield (28.95%) and number of pods per plant (26.05%).High heritability coupled with high genetic advance was observed for the above characters indicating that these characters are governed by additive gene action, hence there lies a good chance of improvement in these traits through direct selection in the present material. Similar findings were reported by Datta and Chatterjee (2004) Naik (2012). Narolia *et.al*. (2017)

Correlation and Path Studies

The estimates of genotypic correlation coefficient were higher than their corresponding phenotypic correlation coefficient values for most of the characters under study (Table 2 and 3). Phenotypic and Genotypic level envisaged that biological yield was having significant and positive correlation with chlorophyll content of the leaves, number of pods per plant, straw yield per plant, 1000 seed weight, dry matter content of the plant as whole and seed yield per plant while negatively correlated with the harvest index. However, biological yield per plant too showed positive and significant correlation with plant height and number of branches per plant only at genotypic level. Similar associations were observed for straw yield per plant, number of pods per plant which too exhibited positive and significant correlation with number of branches per plant, chlorophyll content, straw yield per plant, 1000 seed weight, dry matter content and seed yield per plant, however it was negatively and significantly correlated to harvest index. Number of seeds per pod was positively and significantly associated to dry weight during flower initiation, pod length, protein content and seed yield per plant. Pod length enjoyed a significant and positive correlation with protein content, plant height, dry weight at flowering phase, 1000 seed weight, dry matter content, harvest index and seed yield per plant at genotypic level. Protein content in the seed, too exhibited positive and significant association with number of branches per plant , number of seeds per pod at both phenotypic and genotypic level. Plant height was having positive association with 1000 seed weight, dry matter content, seed yield per plant in a significant manner both at phenotypic and genotypic level. Genotypic path analysis (Table 4) of the different characters revealed that biological yield had highest positive direct effect on seed yield per plant followed by harvest index, dry matter content, chlorophyll content in leaves, number of seeds per pod, dry weight at flower initiation, number of pods per plant, 1000 seed weight and number of branches per plant. The straw yield per plant and pod length had the highest negative direct effect on seed yield followed by days to 50% flowering, plant height and protein content in seed. Phenotypic path analysis (Table 5) of the different characters revealed that biological yield per plant had highest positive direct effect on seed yield per plant followed by harvest index, dry weight at flower initiation, chlorophyll content in leaves, number of branches per plant and 1000 seed weight. Straw yield per plant and plant height

Table 1. Genetic parameter of yield and yield attributing characters in fenugreek genotypes

Character	Mean	Range		PCV%	GCV%	Heritability (BS) %	Genetic Advance	Genetic advance as percentage of mean
		Min.	Max.					
Plant height (cm)	65.91	46.20	74.83	9.89	8.74	78.2	10.50	15.93
No. of branches/plant	14.60	11.23	16.20	10.99	6.42	34.2	1.13	7.73
Dry weight at flower initiation(g)	3.86	2.23	5.27	22.56	21.36	89.7	1.61	14.70
Chlorophyll content in leaves (SPAD Unit)	54.11	45.47	59.47	7.19	6.71	87.1	6.98	12.89
No. of pods/plant	66.74	51.10	80.14	13.08	12.86	96.7	17.39	26.05
No. of seeds / pod	15.50	13.86	17.47	7.32	5.92	65.4	1.53	9.87
Pod length (cm)	11.12	9.82	12.19	7.10	3.51	24.4	0.40	3.59
Biological yield/plant (g)	37.13	26.20	46.83	17.97	15.89	78.2	10.75	28.95
Straw yield per plant (gm)	24.92	13.50	33.62	21.63	18.23	71.0	7.89	31.66
Protein content in seed (%)	18.91	14.03	25.53	15.46	15.23	96.9	5.84	30.88
Days to 50% flowering	48.41	43.67	53.33	5.19	4.32	69.4	3.56	7.35
1000 seed wt (g)	14.41	11.10	19.10	14.08	12.97	84.8	3.55	24.63
Dry matter content (g)	56.48	39.53	75.23	19.06	17.09	80.4	17.83	31.56
Harvest index	34.19	27.89	50.24	16.16	12.32	58.1	6.62	19.36
Seed yield /plant(g)	12.49	9.77	17.03	16.02	13.30	68.9	2.84	22.73

Table 2. Genotypic correlation coefficient of yield and its component characters of fenugreek

Characters	Plant height (cm)	No. of branches/ plant	Dry wt at flower initiation (g)	Chlorophyll content (SPAD Unit)	No. of pods/ plant	No. of seeds/ Pod	Pod length (cm)	Biological yield/plant(g)	Straw yield/ plant (g)	Protein content in seed (%)	Days to 50% flowering	1000 seed wt (g)	Dry matter content (g)	Harvest index	Seed yield /plant (g)
Plant height (cm)		-0.049	0.283	0.413*	0.286	0.196	0.607**	0.430*	0.337*	0.101	-0.150	0.683**	0.588**	-0.177	0.413*
No. of branches/ plant			-0.153	0.594**	0.592**	0.272	-0.052	0.456**	0.449**	0.653**	-0.247	0.509**	0.160	-0.060	0.515**
Dry wt at flo. initiation (g)				0.069	0.240	0.482**	0.580**	0.200	0.161	0.241	0.017	0.300	0.253	-0.008	0.288
Chlorophyll (SPAD Unit)					0.380*	-0.147	0.031	0.518**	0.527**	0.181	-0.106	0.581**	0.207	-0.293	0.420*
No. of pods/plant						0.321	0.161	0.850**	0.826**	0.318	-0.169	0.375*	0.538**	-0.428*	0.680**
No. of seeds/pod							0.773**	0.215	0.089	0.567**	-0.086	0.386*	0.400*	0.226	0.483**
Pod length (cm)								0.248	0.056	0.445**	-0.300	0.462**	0.674**	0.356*	0.646**
Biological yield/p (g)									0.969**	0.213	-0.167	0.609**	0.749**	-0.607**	0.741**
Straw yield per plant (gm)										0.096	-0.041	0.532**	0.632**	-0.755**	0.575**
Protein content in seed (%)											-0.073	0.275	0.448**	0.329	0.550**
Days to 50% flowering												-0.433**	-0.314	-0.411*	-0.572**
1000 seed wt (g)													0.522**	-0.105	0.690**
Dry matter content (g)														-0.193	0.759**
Harvest index															0.073
Seed yield /plant(g)															

** 1% level of significance * 5% level of significance

Table 3. Phenotypic correlation coefficient of yield and its component characters of fenugreek

Characters	Plant height (cm)	No. of branches/ plant	Dry wt. at flower initiation (g)	Chlorophyll (SPAD Unit)	No. of pods/ plant	No. of seeds/ Pod	Pod length (cm)	Biological yield/plant(g)	Straw yield per plant (gm)	Protein content in seed (%)	Days to 50% flowering	1000 seed wt (g)	Dry matter content (g)	Harvest index	Seed yield /plant (g)
Plant height (cm)		0.011	0.219	0.341*	0.235	0.123	0.270	0.326	0.217	0.097	-0.093	0.558**	0.486**	-0.108	0.297
No. of branches/ plant			-0.077	0.265	0.355*	0.030	-0.046	0.285	0.207	0.379*	-0.023	0.268	0.184	0.032	0.401*
Dry wt at flo. initiation (g)				0.063	0.220	0.407*	0.310	0.162	0.118	0.224	0.027	0.252	0.207	0.031	0.258
Chlorophyll (SPAD Unit)					0.351*	-0.106	-0.049	0.419*	0.411*	0.167	-0.047	0.512**	0.192	-0.039	0.289
No. of pods/plant						0.196	0.071	0.770**	0.713**	0.310	-0.152	0.351*	0.487**	-0.356*	0.560**
No. of seeds/pod							0.390*	0.128	0.006	0.455**	-0.169	0.223	0.279	0.196	0.371*
Pod length (cm)								0.063	-0.035	0.211	-0.171	0.167	0.272	0.231	0.304
Biological yield/p (g)									0.953**	0.189	-0.106	0.479**	0.634**	-0.573**	0.623**
Straw yield per plant (gm)										0.086	-0.022	0.398*	0.494**	-0.750**	0.385*
Protein content in seed (%)											-0.051	0.254	0.399*	0.232	0.437**
Days to 50% flowering												-0.353*	-0.218	-0.265	-0.375*
1000 seed wt (g)													0.419*	-0.096	0.498**
Dry matter content (g)														-0.013	0.639**
Harvest index															0.263
Seed yield /plant(g)															

** 1% level of significance * 5% level of significance

Table 4. Genotypic path coefficient of yield and its component characters of fenugreek (Dependable variable-seed yield per plant)

Characters	Plant height (cm)	No. of branches/ plant	Dry wt. at flower initiation (g)	Chloro phyll (SPAD Unit)	No. of pods/ plant	No. of seeds/ Pod	Pod length (cm)	Biological yield/plant (g)	Straw yield per plant (g)	Protein content in seed (%)	Days to 50% flowering	1000 seed wt (g)	Dry matter content (g)	Harvest index
Plant height (cm)	-0.059	0.000	0.032	0.173	0.012	0.033	-0.145	0.792**	-0.366*	-0.006	0.013	0.007	0.166	-0.088
No. of branches/ plant	0.003	0.000	-0.017	0.103	0.026	0.046	0. 012	0.839**	-0.489**	-0.036	0.021	0.006	0.032	-0.030
Dry wt. at flo. initiation (g)	-0.017	0.000	0.112	0.012	0.010	0.082	-0.139	0.367*	-0.175	-0.013	0.001	0.003	0.050	-0.004
Chlorophyll (SPAD Unit)	-0.024	0.000	0.008	0.173	0.016	-0.025	-0.007	0.954**	-0.574**	-0.010	-0.009	0.006	0.041	-0.146
No. of pods/plant	-0.017	0.000	0.027	0.066	0.043	0.039	-0.039	1.566**	-0.900**	-0.017	0.014	0.004	0.106	-0.213
No. of seeds/pod	-0.011	0.000	0.054	-0.025	0.010	0.171	-0.185	0.395*	-0.096	-0.031	0.007	0.004	0.079	0.112
Pod length (cm)	-0.036	0.000	0.065	0.005	0.007	0.132	-0.239	0.456**	-0.061	-0.024	0.025	0.005	0.133	0.177
Biological yield/p (g)	-0.025	0.000	0.022	0.090	0.337*	0.037	-0.059	1.841**	-1.055**	-0.012	0.014	0.007	0.148	-0.302
Straw yield per plant (gm)	-0.020	0.000	0.018	0.091	0.036	0.015	-0.013	1.785**	-1.089**	-0.005	0.003	0.006	0.125	-0.376*
Protein content in seed (%)	-0.006	0.000	0.027	0.031	0.014	0.097	-0.106	0.392*	-0.104	-0.055	0.006	0.003	0.088	0.164
Days to 50% flowering	0.009	0.000	0.002	-0.018	-0.007	-0.015	0.072	-0.308	0.044	0.004	-0.084	-0.005	-0.062	-0.205
1000 seed wt (g)	-0.040	0.000	0.034	0.101	0.016	0.066	-0.111	1.121**	-0.579**	-0.015	0.036	0.011	0.103	-0.052
Dry matter content (g)	-0.034	0.000	0.028	0.036	0.026	0.068	-0.161	1.379**	-0.688**	-0.024	0.026	0.006	0.197	-0.096
Harvest index	0.010	0.000	-0.001	-0.051	-0.018	0.039	-0.085	-1.117**	0.822**	-0.018	0.034	-0.001	-0.038	0.498**

** 1% level of significance * 5% level of significance

Table 5. Phenotypic path coefficient of yield and its component characters of fenugreek (Dependable variable-seed yield per plant)

Characters	Plant height (cm)	No. of branches/ plant	Dry wt. at flower initiation (g)	Chlorophyll (SPAD Unit)	No. of pods/ plant	No. of seeds/ Pod	Pod length (cm)	Biological yield/plant(g)	Straw yield per plant (gm)	Protein content in seed (%)	Days to 50% flowering	1000 seed wt (g)	Dry matter content (g)	Harvest index
Plant height (cm)	-0.079	0.000	0.014	0.017	-0.004	0.000	0.004	0.583**	-0.189	-0.001	0.003	0.018	-0.004	-0.067
No. of branches/ plant	-0.001	0.046	-0.005	0.013	-0.006	0.000	-0.001	0.511**	-0.181	-0.003	0.001	0.009	-0.002	0.020
Dry wt. flower initiation (g)	-0.017	-0.004	0.064	0.003	-0.004	0.001	0.005	0.290	-0.103	-0.002	-0.001	0.008	-0.002	0.019
Chlorophyll (SPAD Unit)	-0.027	0.012	0.004	0.049	-0.006	0.000	-0.001	0.749**	-0359*	-0.001	0.002	0.017	-0.002	-0.148
No. of pods/plant	-0.019	0.016	0.014	0.017	-0.017	0.000	0.001	1.379*	-0.623**	-0.002	0.005	0.012	-0.004	-0.220
No. of seeds/pod	-0.010	0.001	0.026	-0.005	-0.003	0.002	0.006	0.230	-0.005	-0.003	0.006	0.007	-0.002	0.121
Pod length (cm)	-0.021	-0.002	0.020	-0.002	-0.001	0.001	0.017	0.113	0.031	-0.002	0.006	0.006	-0.002	0.143
Biological yield/plant(g)	-0.026	0.013	0.010	0.021	-0.013	0.000	0.001	1.790**	-0.832**	-0.001	0.004	0.016	-0.006	-0.353
Straw yield per plant (gm)	-0.017	0.009	0.008	0.020	-0.012	0.000	-0.001	1.705**	-0.874**	-0.001	0.001	0.013	-0.004	-0.463
Protein content in seed (%)	-0.008	0.017	0.014	0.028	-0.005	0.001	0.004	0.338*	-0.075	-0.007	0.002	0.008	-0.004	0.143
Days to 50% flowering	0.007	-0.001	0.020	-0.020	0.003	0.000	-0.003	-0.190	0.109	0.000	-0.035	-0.012	0.002	-0.164
1000 seed wt (g)	-0.044	0.012	0.016	0.025	-0.006	0.001	0.003	0.858**	-0.348*	-0.002	0.013	0.033	-0.004	-0.059
Dry matter content (g)	-0.039	0.008	0.013	0.029	-0.008	0.001	0.005	1.136**	-0.432**	-0.003	0.008	0.014	-0.009	-0.064
Harvest index	0.009	0.001	0.020	-0.012	0.006	0.000	0.004	-1.025**	0.655**	-0.002	0.009	-0.003	0.001	0.617**

** 1% level of significance * 5% level of significance

had the highest negative direct effect on seed yield. Traits like straw yield per plant and plant height imparted negative direct effect on seed yield per plant. Thus, for increasing seed yield per plant d emphasis on traits having positive and direct effect should be given due importance and balanced selection based on these traits would be more rewarding for improvement of fenugreek. Similar observations have been cited by scientists like Dashora *et al.* (2011), Naik *et al.* (2011) Fikreselassie *et al.* (2012) and Kumar *et.al.* (2018)

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