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Designing Selection Criteria by Using Association Studies and Estimation of Genetic Diversity in Fenugreek (*Trigonella foenum-graecum* L.) Germplasm

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ABSTRACT

An investigation consisting of 36 fenugreek genotypes and one check (Pusa Early Bunching) was laid out in Randomized Block Design with three replications at Pantnagar Centre for Plant Genetic Resources (PCPGR) of the G.B.P.U.A & T, Pantnagar, Uttarakhand during *rabi* season of 2016-17 and 2017-18 and observations were recorded on sixteen different traits. The traits *viz*., number of pods per plant, thousand seed weight and leaf yield per plant exhibited high direct effects on seed yield per plant along with significant positive correlation indicating that these traits can be used as most important selection criteria for seed yield improvement. The diversity analysis leads to formation of nine different clusters and maximum intra-cluster distance was observed in cluster IV (21.07) while highest inter-cluster distance was recorded between cluster VII and IV (46.07). These clusters actually represent the different heterotic pools and genotypes from diverse pools can be crossed to obtain heterosis and transgressive segregants.

Key words: Association, Fenugreek, Genetic diversity, Variability.

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L.) is an important seed spice cum leafy vegetable crop belonging to the family fabaceae. It is a self-pollinated diploid species with sixteen chromosome number (Frayer, 1930). Fenugreek is a dicotyledonous crop with light green, pinnately trifoliate leaves (Srinivasan, 2006) and yellow-white papilionaceous flowers. Commercially, it has high economic value as food, fodder and medicine. Fenugreek has a wider adaptability and is grown under wide range of climatic conditions. The study on morphological parameters and their association with the sink potential is a modal tool for designing suitable selection criteria in fenugreek. Yield improvement of any crop mainly depends on the presence of genetic diversity in elite as well as wild lines. Genetic diversity can be explained as different types of alleles and genotypes present in a population that results in differences between individuals and populations at morphological, physiological and behavioural level (Frankham *et al.,* 2002). There is an urgent need to evaluate genetic diversity of existing genotypes for development of promising and high yielding cultivars. There is need to assess and improve the existing genotypes and introduce suitable varieties of fenugreek which can be used both as leafy vegetable as well as for seed purpose. Despite of having a large global genetic diversity only some well-defined cultivars are grown in specific areas. The knowledge about the diversity of different genotypes is very important as it helps us to broaden the genetic base, reduction of genetic erosion and heterotic pooling.

MATERIALS AND METHODS

The present investigation was conducted at Pantnagar Centre for Plant Genetic Resources (PCPGR) of the GBPUA&T, Pantnagar, Uttarakhand during *rabi* season of 2016-17 and 2017-18. The experiment consisting of 36 fenugreek genotypes and one check (Pusa Early Bunching) was laid out in RBD with three replications and spacing of 30 cm (row to row) and 10cm (plant to plant). From each plot in each replication, five plants were randomly selected and observations were recorded in both the years for sixteen different morphological characters. The recorded data of both the years was pooled and then subjected to statistical analysis. The analysis of variance (ANOVA) was done following the method given by Fisher (1920). The genotypic and phenotypic coefficients of variation (GCV and PCV),

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for various traits were calculated by the formula suggested by Burton and De Vane (1953). Heritability in broad sense was also calculated by formula given by Burton and De Vane (1953). The genetic advance was calculated by formula given by Robinson *et al*. (1949) and genetic advance as percentage over mean was calculated by using formula of Johnson *et al.* (1955). Direct and indirect effects of various characters on seed yield were computed by using the formula suggested by Dewey and Lu (1959). To estimate genetic diversity Mahalanobis D^2 statistics (Mahalanobis, 1928) was used and clusters were prepared by following the Tocher's method as described by Rao (1952).

RESULTS AND DISCUSSION

The ultimate objective of any plant breeding programme is to develop promising genotypes which have higher potential in producing economic yield than the existing varieties of the crop. Presence of genetic variability determines the success of such breeding programmes and various variability parameters are used so that desirable and ideal genotypes can be selected. Hence, plant breeder need to have the knowledge of association of yield with component traits as well as among themselves.

Association studies by using yield and related traits (Pooled Analysis of Variance)

Analysis of variance (ANOVA) for various morphological characters of fenugreek for the pooled data of year 2016-17 and 2017-18 are presented in Table 1. It revealed highly significant differences among the genotypes for all the sixteen traits *viz.,* number of primary branches per plant, number of leaves per plant at 30 days, 45 days and 60 days after sowing, plant height, days to first flowering, node of first flowering, days to 50 per cent flowering, days to seed maturity, number of pods per plant, pod length, pod width, number of seeds per pod, thousands seed weight, green leaf yield per plant and seed yield per plant. Thus wide range of genetic variability was present in the genotypes for all the traits which can be exploited for development of superior varieties. Similar results were0obtained by Singh and Chandra *et al.* (2000), Kakani (2017), Singh and Naula (2017), Yadav *et al.* (2017), Naula *et al.* (2018) and Pant *et al.* (2018).

Genetic variability parameters

The study of pooled data revealed that in general for all the studied traits PCV was higher than the GCV (Table 2) indicating the presence of considerable amount of genetic variability in genotypes. High estimate (> 20%) of genotypic coefficient of variation was obtained for leaf yield per plant (27.78%) followed by number of pods per plant (21.38%), thousands seed weight (21.31%), number of leaves per plant at 60 DAS (20.56%). The estimates of phenotypic coefficient of variation was recorded high (>20%) for leaf yield per plant (28.99%) followed by thousands seed weight (21.99%), number of pods per plant (21.61%), number of

Table 1: Analysis of variance for different quantitative characters in fenugreek.

S.V.	df	Mean Sum of Squares													
		PBP	NLP (30 days)	NLP (45 days)	NLP (60 days)	PH	DFF	NFF	DTF 50 %	DMs	NPP	PL	PW	NSP	1000 SW	LY/P	SY/P
R	2	0.135	0.173	9.676	15.732*	11.832	0.11	0.061	0.097	1.811*	18.527*	0.585	0.018	0.19	0.661*	0.032	1.448**
T	36	0.725**	16.917**	146.726**	897.616**	257.976**	63.525**	1.732**	14.969**	4.277**	669.172**	1.075**	0.127**	4.768**	8.548	4.943**	18.040**
E	72	0.056	0.477	3.75	4.73	4.274	0.907	0.042	0.819	0.447	4.824	0.227	0.01	0.71	0.191	0.143	0.274

** significant at 1%, * significant at 5%

Here, PBP= Number of primary branches per plant, NLP= Number of leaves/plant at 30 days, 45 days & 60 days after sowing, PH= Plant Height (cm), DFF= Days to first flowering, NFF= Node of first flowering, DTF50 %= Days to 50 % flowering, DMs= Days to seed maturity, NPP= Number of pods per plant, PL= Pod length (cm), PW= Pod width (mm), NSP= Number of seeds per pod, 1000 SW= Seed Weight (g), LY/P= Green leaf yield per plant (g), SY/P= Seed yield per plant (g).

Table 2: Estimates of genetic parameters of variation for the different morphological characters of fenugreek genotypes.

Characters	Mean	Range	Genotypic coefficient of variance	Phenotypic coefficient of variance	Heritability (%)	Genetic advance	Genetic advance as percent of mean (%)
PBP	3.94	3.15-5.33	11.97	13.38	80.06	0.87	22.07
NLP (30 days)	13.56	9.48-18.40	17.27	18.01	91.99	4.63	34.12
NLP (45 days)	40.38	25.30-58.97	17.1	17.76	92.71	13.69	33.91
NLP (60 days)	83.89	48.28-125.30	20.57	20.73	98.44	35.26	42.03
PH	54.09	31.39-71.76	17	17.43	95.19	18.48	34.17
DFF	73.40	66.83-83.83	6.22	6.36	95.84	9.21	12.55
NFF	5.98	3.83-6.95	12.55	13	93.14	1.49	24.95
DTF 50 %	90.56	87.50-96.50	2.4	2.6	85.2	4.13	4.56
DMs	134.78	132.5-137	0.84	0.97	74.05	2	1.49
NPP	69.58	49.60-99.84	21.39	21.62	97.87	30.33	43.59
PL	9.62	7.52-10.54	5.53	7.42	55.42	0.82	8.47
PW	1.91	1.48-2.32	10.3	11.6	78.91	0.36	18.86
NSP	15.15	12.47-18.20	7.68	9.48	65.59	1.94	12.81
1000 SW	8.17	5.85-11.94	20.43	21.12	93.57	3.33	40.71
LY/P	4.55	1.95-7.74	27.78	29	91.79	2.5	54.83
SY/P	9.38	5.05-15.85	25.94	26.53	95.58	4.9	52.24

leaves per plant at 60 DAS (20.72%), seed yield per plant (20.68%). The characters *viz.,* number of leaves per plant at 60 DAS (98.43%), number of pods per plant (97.86%), days to first flowering (95.83%), plant height (95.18%), thousands seed weight (93.88%), node of first flowering (93.13%), number of leaves per plant at 45 DAS (92.70%), number of leaves per plant at 30 DAS (91.99%), leaf yield per plant (91.78%), seed yield per plant (91.18%), days to 50% flowering (85.20%), primary branches per plant (80.05%), pod width (78.91%), days to seed maturity (74.04%) and number of seeds per pod (65.58%) showed high estimates (>60%) of heritability (Table 2). Highest estimate (>20%) of genetic advance as per cent of mean was obtained for leaf yield per plant (54.83 %) followed by number of pods per plant (43.58%), thousands seed weight (42.53%), number of leaves per plant at 60 DAS (42.03%), seed yield per plant (38.85%), plant height (34.16%), number of leaves per plant at 30 DAS (34.12%), number of leaves per plant at 45 DAS (33.90%), node of first flowering (24.94%) and primary branches per plant (22.06%).

The traits showing high heritability along with high genetic advance were number of pods per plant, number of leaves per plant at 30, 45 and 60 DAS, thousands seed weight, node of first flowering, leaf yield per plant, primary branches per plant and seed yield per plant. The high heritability coupled with high genetic advance indicates the presence of additive gene action. Similarly, high heritability0coupled with0genetic advance0as per cent of mean0was reported for number of pods per plant by Prajapati *et al.* (2007), Plant height by Lodhi *et al.* (2015) thousands seed weight by Banerjee and Kole (2004) for seed yield per plant by Yadav *et al.* (2013), Singh and Kakani (2017) and Yadav *et al.* (2017).

Association Studies by using correlation and path coefficient

The study of correlation revealed that in general the magnitude of genetic correlation was higher than the phenotypic correlation (Table 3). Pooled analysis of both years' data revealed that seed yield per plant showed significant and positive association with number of leaves per plant at 45 DAS (r_p=0.157, r_g=0.186*), plant height (r_p=0.313**, r_g=0.327**), number of pods per plant (r_p=0.500**, r_g=0.524**), pod length (r_p=0.226*, r_g=0.280**), pod width (r_p=0.227*, r_g=0.223*), thousands seed weight (r_p=0.347**, r_g=0.372**) and leaf yield per plant (r_p=0.230*, r_g=0.257**). The correlation of these traits with seed yield indicates that these traits could be selected directly to improve the seed yield per plant.

Positive association of seed yield per plant with number of pods per plant was also reported by Fufa (2013), Lodhi *et al.* (2015), Wojo *et al.* (2016) and Patil (2018) with plant height by Jain *et al.* (2013), Lodhi *et al.* (2015), Singh and Kakani (2017) and Panwar *et al.* (2018) with pod length was by Wojo *et al.* (2016) and Panwar *et al.* (2018) with pod width by Panwar *et al.* (2018) with leaf yield per plant by Lodhi *et al.* (2015), Gurjar *et al.* (2016) and Singh *et al.* (2016) with thousands seed weight was also obtained by Jain *et al.* (2013), Singh (2014), Lodhi *et al.* (2015), Gurjar *et al.* (2016), Wojo *et al.* (2016) and Panwar *et al.* (2018). High positive direct effect (0.3-0.99) on seed yield per plant were showed by number of pods per plant (0.852), thousands seed weight (0.424), green leaf yield per plant (0.376) and days to 50 per cent flowering (0.345) (Table 4).

The traits like number of pods per plant, thousand seed weight and leaf yield per plant exhibited high direct effects on seed yield per plant along with significant positive

Table 3: Phenotypic (P) and genotypic (G) correlation coefficients between seed yield and different morphological characters in Fenugreek.

Characters		PBP	NLP (30 days)	NLP (45 days)	NLP (60 days)	PH	DFF	NFF	DTF 50 %	DMs	NPP	PL	PW	NSP	1000 SW	LY/P	SY/P
PBP	P	1.000	-0.240*	-0.111	0.036	-0.543**	0.736**	-0.199*	0.619**	0.205*	0.203*	-0.169	-0.335**	0.183	-0.391**	-0.229*	0.015
	G	1.000	-0.280**	-0.129	0.045	-0.612**	0.831**	-0.245**	0.758**	0.278**	0.219*	-0.326**	-0.416**	0.291**	-0.474**	-0.277**	0.021
NLP(30 days)	P		1.000	0.702**	0.579**	0.234*	-0.276**	0.276**	-0.17	-0.163	-0.07	0.318**	0.447**	-0.076	0.303**	0.403**	-0.066
	G		1.000	0.752**	0.607**	0.251**	-0.297**	0.305**	-0.186*	-0.171	-0.063	0.436**	0.474**	-0.107	0.318**	0.452**	-0.069
NLP (45 days)	P			1.000	0.883**	-0.072	-0.210*	-0.211*	-0.155	-0.181	0.322**	-0.062	0.076	-0.232*	-0.004	0.589**	0.178
	G			1.000	0.923**	-0.068	-0.219*	-0.239*	-0.169	-0.198*	0.344**	-0.051	0.091	-0.300**	0.005	0.624**	0.198*
NLP (60 days)	P				1.000	-0.215*	-0.104	-0.368**	-0.089	-0.131	0.370**	-0.12	-0.111	-0.193*	-0.175	0.607**	0.204*
	G				1.000	-0.215*	-0.1	-0.387**	-0.086	-0.14	0.380**	-0.171	-0.131	-0.250**	-0.190*	0.633**	0.208*
PH	P					1.000	-0.575**	0.548**	-0.510**	-0.039	-0.372**	0.463**	0.569**	0.062	0.672**	0.16	0.003
	G					1.000	-0.606**	0.574**	-0.572**	-0.031	-0.389**	0.624**	0.653**	0.067	0.721**	0.172	-0.004
DFF	P						1.000	-0.218*	0.855**	0.238*	0.264**	-0.179	-0.390**	0.359**	-0.567**	-0.497**	-0.03
	G						1.000	-0.222*	0.948**	0.284**	0.272**	-0.231*	-0.442**	0.510**	-0.592**	-0.530**	-0.028
NFF	P							1.000	-0.15	0.17	-0.411**	0.495**	0.620**	0.123	0.623**	-0.012	-0.092
	G							1.000	-0.18	0.203*	-0.438**	0.662**	0.728**	0.177	0.661**	-0.029	-0.097
DTF 50 %	P								1.000	0.289**	0.146	-0.046	-0.360**	0.436**	-0.475**	-0.499**	-0.017
	G								1.000	0.308**	0.156	-0.058	-0.383**	0.614**	-0.520**	-0.524**	-0.011
DMs	P									1.000	-0.082	0.027	0.016	0.243**	-0.133	-0.111	-0.038
	G									1.000	-0.094	0.098	0.065	0.377**	-0.157	-0.148	0.657**
NPP	P										1.000	-0.314**	-0.378**	-0.088	-0.374**	0.095	0.676**
	G										1.000	-0.415**	-0.425**	-0.091	-0.393**	0.106	-0.077
PL	P											1.000	0.455**	0.345**	0.425**	-0.048	-0.128
	G											1.000	0.646**	0.453**	0.558**	-0.105	-0.049
PW	P												1.000	-0.1	0.692**	0.272**	-0.088
	G												1.000	-0.262**	0.808**	0.305**	0.013
NSP	P													1.000	-0.266**	-0.392**	-0.03
	G													1.000	-0.328**	-0.535**	0.092
1000 SW	P														1.000	0.319**	0.097
	G														1.000	0.341**	0.324**
LY/P	P															1.000	0.350**
	G															1.000	0.015
SY/P	P																1.000
	G																1.000

*Significant at p=0.05 or at 5 % and **Significant at p=0.01 or at 1%.

Table 4: Path coefficient analysis showing direct and indirect effect of various characters on seed yield at phenotypic level.

Characters	Correla-tion with SY/P	Direct effect	Indirect effect via PBP	NLP (30 days)	NLP (45 days)	NLP (60 days)	PH	DFF	NFF	DTF 50 %	DMs	NPP	PL	PW	NSP	1000 SW	LY/P
PBP	0.015	-0.022	-	0.048	0.023	0.003	-0.009	-0.204	0.003	0.214	-0.005	0.173	0.014	-0.022	0.054	-0.166	-0.086
NLP(30 days)	-0.066	-0.199	0.005	-	-0.143	0.047	0.004	0.077	-0.004	-0.059	0.004	-0.060	-0.026	0.029	-0.022	0.128	0.152
NLP(45 days)	0.178	-0.203	0.003	-0.139	-	0.071	-0.001	0.058	0.003	-0.054	0.005	0.275	0.005	0.005	-0.069	-0.002	0.222
NLP(60 days)	0.204*	0.08	-0.001	-0.115	-0.179	-	-0.004	0.029	0.005	-0.031	0.003	0.316	0.010	-0.007	-0.057	-0.074	0.228
PH	0.003	0.017	0.012	-0.047	0.015	-0.017	-	0.159	-0.008	-0.176	0.001	-0.317	-0.037	0.037	0.018	0.285	0.060
DFF	-0.03	-0.277	-0.017	0.055	0.043	-0.008	-0.010	-	0.003	0.295	-0.006	0.225	0.014	-0.025	0.106	-0.240	-0.187
NFF	-0.092	-0.014	0.005	-0.055	0.043	-0.030	0.010	0.060	-	-0.052	-0.004	-0.351	-0.040	0.040	0.036	0.264	-0.005
DTF 50 %	-0.017	0.345	-0.014	0.034	0.032	-0.007	-0.009	-0.237	0.002	-	-0.007	0.125	0.004	-0.023	0.129	-0.201	-0.188
DMs	-0.038	-0.026	-0.005	0.032	0.037	-0.011	-0.001	-0.066	-0.002	0.100	-	-0.070	-0.002	0.001	0.072	-0.056	-0.042
NPP	0.657**	0.852	-0.005	0.014	-0.066	0.030	-0.006	-0.073	0.006	0.051	0.002	-	0.025	-0.025	-0.026	-0.158	0.036
PL	-0.077	-0.081	0.004	-0.063	0.013	-0.010	0.008	0.050	-0.007	-0.016	-0.001	-0.268	-	0.030	0.102	0.180	-0.018
PW	-0.049	0.065	0.008	-0.089	-0.015	-0.009	0.010	0.108	-0.009	-0.124	0.000	-0.322	-0.037	-	-0.030	0.293	0.102
NSP	0.013	0.296	-0.004	0.015	0.047	-0.016	0.001	-0.100	-0.002	0.150	-0.006	-0.075	-0.028	-0.007	-	-0.113	-0.148
1000 SW	0.092	0.424	0.009	-0.060	0.001	-0.014	0.012	0.157	-0.009	-0.164	0.003	-0.319	-0.034	0.045	-0.079	-	0.120
LY/P	0.324**	0.376	0.005	-0.080	-0.120	0.049	0.003	0.138	0.000	-0.172	0.003	0.081	0.004	0.018	-0.116	0.135	-

Residual effect = 0.2747.

Table 5: Classification of fenugreek genotypes into different clusters based on D^2 value.

Cluster number	Number of genotypes	Genotypes included
I	15	PCPGR-GP-2011-285, PFG-13, PFG-6, PFG-7, PFG-12, PFG-18, PFG-16, PCPGR-GP-2011-127, PFG-5, PFG-21, PCPGR-5958, PCPGR-7930, PCPGR-5938, PFG-41 and PCPGR-GP-2011-248
II	9	PCPGR-GP-2011-165, PCPGR-GP-2011-188, PCPGR-7928, PCPGR-7368, PCPGR-7927, PCPGR-GP-2011-158, PCPGR-GP-2011-133, PFG-9 and Pusa Early Bunching
III	1	PFG-4
IV	6	PCPGR-2983, PFG-40, PCPGR-5984, PCPGR-6023, PCPGR-GP-2011-96 and PFG-14
V	1	PFG-10
VI	1	PCPGR-GP-2011-572
VII	1	PCPGR-GP-2011-196
VIII	1	ER-2011-485
IX	1	PFG-42

Table 6: Inter and intra cluster distances of four clusters of fenugreek genotypes.

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII	Cluster IX
Cluster I	**15.64**	24.31	25.06	34.82	20.20	20.75	27.83	21.67	36.44
Cluster II		**17.54**	24.36	28.65	23.25	28.61	26.54	29.32	22.91
Cluster III			**0.00**	27.58	13.91	35.45	30.26	37.92	31.07
Cluster IV				**21.07**	25.32	40.22	46.07	45.97	27.12
Cluster V					**0.00**	29.31	33.00	34.31	32.28
Cluster VI						**0.00**	32.42	20.72	37.55
Cluster VII							**0.00**	24.74	36.36
Cluster VIII								**0.00**	42.39
Cluster IX									**0.00**

correlation indicating that these traits could be used as most important selection criteria for seed yield improvement in fenugreek.

Diversity analysis

For a successful crop improvement program, assessment of genetic divergence is very essential. It facilitates the selection of suitable parents for hybridization program. It is well known fact that higher the genetic diversity among the parents greater will be the possibility of getting desirable segregants or heterotic hybrids.

Cluster obtained

The analysis of pooled data results in formation of nine different clusters (Table 5), cluster I (15) contained maximum number of genotypes followed by cluster II (9) and cluster IV (6). Cluster III, cluster V, cluster VI, cluster VII, cluster VIII and cluster IX, each had only one genotype. Similarly, the fenugreek genotypes were grouped into 9 clusters by Pathak *et al.* (2014), 5 clusters by Kakani *et al.* (2015), 6 clusters by Wojo *et al.* (2015), 4 clusters by Tariyal *et al.* (2017) and 2 clusters by Panwar *et al.* (2018).

Among eight clusters, maximum intra cluster distance (Table 6) was observed in cluster IV (21.07) followed by cluster II (17.54) and cluster I (15.64) while other clusters showed no intra cluster distances. Highest inter cluster distance was recorded between cluster VII and IV (46.07) followed by cluster VIII and IV (45.97), cluster IX and VIII (42.39), cluster VI and IV (40.22) and cluster VIII and III (37.92). The least inter cluster distance was observed in between cluster V and III (13.91). Similar findings of intra and inter cluster distances were observed by Kole and Goswami (2015), Wojo *et al.* (2015), Tariyal *et al.* (2017), Panwar *et al.* (2018), Sindhu *et al.* (2018) and Yadav *et al.* (2018).

Contribution of characters to divergence

During the pooled analysis, among all the sixteen characters, number of pods per plant (31.68%) showed maximum contribution followed by number of leaves per plant at 60 DAS (25.68%), days to first flowering (10.96%), plant height (8.41%), seed yield per plant (7.36%), thousands seed weight (4.05%), green leaf yield per plant (3.60%), number of seeds per pod (3.30%), node of first flowering (2.40%), number of leaves per plant at 30 DAS (1.35%), number of primary branches per plant (0.30%), days to 50 per cent flowering (0.30%), days to seed maturity (0.30%), number of leaves per plant at 45 DAS (0.15%) and pod width (0.15%). The character, pod length showed negligible contribution towards the genetic divergence (Table 7). Similarly, pod number, thousands seed weight and number of primary branches per plant by Mathur *et al.* (1992), plant height by Jain *et al.* (2006) and test weight by Panwar *et al.* (2018) were reported as main contributing characters towards the total genetic divergence.

Table 7: Contribution of different characters towards the divergence.

Characters	Contribution %
Number of primary branches per plant	0.30%
Number of leaves per plant at 30 days after sowing	1.35%
Number of leaves per plant at 45 days after sowing	0.15%
Number of leaves per plant at 60 days after sowing	25.68%
Plant height	8.41%
Days to first flowering	10.96%
Node of first flowering	2.40%
Days to 50 per cent flowering	0.30%
Days to seed maturity	0.30%
Number of pods per plant	31.68%
Pod length	0.00%
Pod width	0.15%
Number of seeds per pod	3.30%
Thousands seed weight	4.05%
Green leaf yield per plant	3.60%
Seed yield per plant	7.36%

The above obtained results provides clue about the presence of sufficient genetic diversity among the genotypes under investigation. The grouping of genotypes in different clusters is highly useful as these groups represent the heterotic pools and genotypes from diverse groups can be crossed to obtain heterosis and transgressive segregants.

CONCLUSION

It can be concluded that there is considerable amount of genetic variability present in the experimental material. Number of pods per plant, thousand seed weight and leaf yield per plant exhibited high direct effects on seed yield per plant along with significant positive correlation indicating that these traits can be used as most important selection criteria for seed yield improvement in fenugreek. The analysis of pooled data results in formation of nine different clusters with highest inter cluster distance was recorded between cluster VII and IV (46.07). These clusters represent the heterotic pools and genotypes from diverse groups can be crossed to obtain heterosis and transgressive segregants.

REFERENCES

Banerjee, A. and Kole, P.C. (2004). Genetic variability, correlation and path analysis in fenugreek (*Trigonella foenum-graecum* L.). Journal of Spices and Aromatic Crops. 13**:** 44-48.

Burton, G.W. and De Vane, E.W. (1953). Essstimating heritability in fall fescue (*Festuca arundinacea*) form replicated clonal material. Agronomy Journal. 45: 478-481.

Chandra K., Sastry, E. V. D. and Singh, D. (2000). Genetic variation and character association of seed yield and its component character in fenugreek (*Trigonella foenum-graecum* L.). Agriculture Science Digest. 20: 93-95.

Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of created wheat grass seed production. Agronomy Journal. 51: 515-518.

Fisher, R.A. (1920). A mathematical examination of the methods of determining the accuracy of an observation by the mean error and by the mean square error. Monthly Notices Roy. Astro. Soc. 80: 758-770.

Frankham, R., Ballou, J.D. and Briscoe, D.A. (2002). Introduction to conservation genetics. Cambridge University Press. 233 p.

Frayer, J.K. (1930). Chromosome Atlas of Flowering Plant. Georg Allen and Unwin London. 519 p.

Fufa, M. (2013). Correlation studies on yield and yield components of Fenugreek (*Trigonella foenum-graecum* L.) lines evaluated in South-Eastern Ethiopia. WJAR. 2: 280-282.

Gurjar, M., Naruka, I.S. and Shaktawat, R.P.S. (2016). Variability and correlation analysis in fenugreek (*Trigonella foenum-graecum* L.). Legume Research. 39: 459-465.

Jain, A., Singh, B., Solanki, R.K., Saxena, S.N. and Kakani, R.K. (2013). Genetic variability and character association in fenugreek (*Trigonella foenum- graecum* L.). International Journal of Seed Spices. 3: 22-28.

Jain, U.K., Singh, D., Balai, O.P. and Shiva, K.N. (2006). Genetic divergence in fenugreek (*Trigonella foenum-graecum* L.) germplasm. Journal of Spices and Aromatic Crops. 15: 59-62.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955). Estimates of genetic and environmental variability in soybean. Agronomy Journal. 47: 314-318.

Kakani, R.K., Singh, G. and Saxena, S.N. (2015). Genetic divergence in fenugreek (*Trigonella foenum-graecum* L.). International Journal of Seed Spice. 5: 37-40.

Kole, P.C. and Goswami, T. (2015). Genetic divergence in fenugreek grown under sub-humid subtropical red lateritic belt of Eastern India. Inernational Journal of Bio-resource Environment and Agriculture Sciences. 1: 97-102.

Lodhi, P.S., Singh, P.P., Naruka, I.S., Kushwaha, S.S. and Singh, A.K. (2015). Genetic variability, correlation and path analysis in fenugreek (*Trigonella foenum-graecum* L.). Indian Journal of Horticulture. 72: 429-433.

Mahalanobis, P.C. 1928. A statistical study at Chinese head measure--ment. J. Asiatic Soc. Bengal. 25: 301-377.

Mathur, V.L. (1992). Genetic Divergence in Fenugreek *(Trigonella foenum-graecum* L.). Indian Journal of Genetics and Plant Breeding. 52: 432-434.

Naula, R., Singh, A. and Raghav, M. (2018). Nutritional potentials of fenugreek (*Trigonella foenum-graecum* L.) genotypes: Chemical characterization. International Journal of Chemical Studies. 6: 743-747.

Pant, N.C., Tewari, M., Dhoundiyal, R., Pandey, C.S., Singh, J.P. and Agrawal, S. (2018). Evaluation of micronutrients in fenugreek (*Trigonella foenum-graecum* L.): A viable alternative for micronutrient supplementation. International Journal of Current Microbioogy and Applied Sciences 7: 2446-2464.

Panwar, A., Sharma, Y.K., Meena, R.S., Solanki, R.K., Aishwath, O.P., Singh, R. and Choudhary. S. (2018). Genetic variability, association studies and genetic divergence in Indian fenugreek (*Trigonella foenum- graecum* L.) varieties. Legume Research. 41: 816-821.

Pathak, A.R., Patel, A.I., Joshi, H.K. and Patel, D.A. (2014). Genetic

divergence in fenugreek (*Trigonella foenum-graecum* L.) germplasm. Trends in Biosciences. 7: 295-297.

Patil, J. 2018. Genetic Diversity Studies in Fenugreek (*Trigonella foenum-graecum* L.). Thesis, M.Sc. Dr. Y.S.R. Horticultural University – Venkataramannagudem.

Prajapati, D.B., Badaya, S.N. and Prajapati, B.H. (2007). Genetic variability, character association and path analysis in fenugreek. In: National Seminar on Production, Development, Quality and Export of Seed Spices-Issues and Strategies, NRCSS, Tabiji, Ajmer. 14: 2-3.

Rao, C.R. (1952). Advanced statistical methods inbiometrical research. John Wiley and Sons Inc., New York. 390 p.

Robinson, H.F., Comstock, R.E., Harvey, P.H. (1949). Estimates of heritability and the degree of dominance in corn. Agronomy Journal. 41**:** 353-359.

Sindhu, A., Tehlan, S.K. and Chaudhury, A. (2018). Effect of morpho--logical trait variance on plant yield in different *Trigonella foenum-graecum* L. varieties. Australian Journal of Crop Science. 12: 1-10.

Singh, A. and Naula, R. (2017). Variability parameters for growth and yield characters in fenugreek (*Trigonella* spp.) genotypes. International Journal of Agriculture Science. 9: 4077-4080.

Singh, G. and Kakani, R.K. (2017).Variability, character association and path analysis studies in fenugreek (*Trigonella foenum--graecum* L.). International Journal of Pure and Applied Bioscience. 5: 945-952.

Singh, G. and Kakani, R.K. (2017). Variability, character association and path analysis studies in fenugreek (*Trigonella foenum-graecum* l.). Int. J. Pure App. Biosci. 5: 945-952.

Singh, M.K. (2014). Genetic variability, heretibility, genetic advance and correlation coefficient analysis in fenugreek (*Trigonella foenum-graecum* L.). Hort Flora Research Spectrum. 3: 178-180.

Singh, P.P., Gujar, M. and Naruka, I.S. (2016). Association and path analysis in fenugreek (*Trigonella foenum-graecum*). Indian Journal of Agricultural Sciences. 86: 951-955.

Srinivasan, K. (2006). Fenugreek (*Trigonella foenum-graecum* L.): A review of health beneficial physiological effects. Food Reviews International. 22**:** 203-224.

Tariyal, Y.S., Bisht, S.S., Pant, S.C. and Chauhan, R.S. (2017). Study of genetic divergence in fenugreek (*Trigonella foenum-graecum* L.). Journal of Pharmacognosy and Phytochemistry. 6: 1551-1552.

Wojo, A.A., Alamerew, S., Nebiyu, A. and Menamo, T.(2015). Cluster analyses based on yield and yield components in fenugreek (*Trigonella foenum-graecum* L.) accessions. GJSFR. 15: 41-46.

Wojo, A.A., Alamerew, S., Nebiyu, A. and Menamo, T. (2016). Genotype and phenotype variability studies in fenugreek (*Trigonella foenum-graecum* L.) accessions in Kaffa Zone, South West Ethiopia. Journal of Spices and Aromatic Crops. 25: 159-168.

Yadav, P., Tehlan, S.K. and Deswal, S. (2018). Assessment of genetic divergence in fenugreek (*Trigonella foenum-graecum* L.) based on biological characters. Journal of Pharmaco--gnosy and Phytochemistry. 7: 1257-1260.

Yadav, P., Tehlan, S.K. and Sheokand, R.N. (2017). Genetic variability of Indian fenugreek (*Trigonella foenum-graecum* L.) landraces. International Journal of Current Microbioogy and Applied Sciences. 6: 2686-2691.

Yadav, Y., Yadava, P.S., Pandey, V.P. and Kumar, A. (2013). Genetic variability, correlation and path co-efficient analysis studies in fenugreek (*Trigonella foenum graecum* L.). The Asian Journal of Horticulture. 8(2): 456-459.