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Studies on variability and heritability for different quantitative characters in fenugreek under different environments

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Thirty diverse genotypes of fenugreek were grown in six (E1 to E6) environments during the winter seasons at the Agriculture Farm of Visva-Bharati University, India. The estimates of genotypic and phenotypic coefficients (GCV and PCV) variation in all the environments were moderate for plant height and test weight, and high for branch number, pod number, husk weight, stem weight and seed yield indicating little influence of the environments on the estimates of these two genetic parameters. On the other hand, days to flowering, pod length, seeds per pod and harvest index showed changes in GCV and PCV values with the changes in environments. Pattern of consistency in heritability estimates over six environments revealed that days to flowering and test weight with high heritability were less influenced by environment; pod length and seed yield with moderate heritability were moderately influenced by environment; and harvest index with low heritability was highly influenced by environment. Estimates of heritability were more or less same in E1 and E2 while it changed from high to moderate for plant height, branch number, pod number and seeds per pod and from moderate to low for pod length, husk weight, stem weight and harvest index in other environments. This indicated that E1 and E2 exerted almost similar environmental effect on the genetic expression of the characters, which was supported by almost similar environmental indexes of E1 and E2 for different characters. Changes in heritability in the rest environments might be due to variable environmental effects on the expression of characters.

Key words: Environments, morphological characters fenugreek, heritability, *Trigonella foenum-graecum*, variability.

INTRODUCTION

Fenugreek, commonly known as ‘methi’ in India, is native to South-east Europe and West Asia. It is now cultivated in India, Argentina, Egypt and Mediterranean countries like Southern France, Morocco, Algeria, Ethiopia and Lebanon (Petropoulos, 2002). Fenugreek is an important leguminous crop, which is grown for seeds, leafy vegetables and fodder. It has medicinal values to prevent constipation, remove indigestion and stimulate spleen and liver (Acharya et al., 2007). The average productivity of fenugreek, which is third important seed spice in India is about 1250 kg per hectare, which is considerably low. The primary consideration to bring about genetic

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Table 1. Mean performance and environmental index (Ij) for eleven characters in six environments.

Character	2003-2004 HI (E1)		2004-2005 HI (E2)		2003-2004 LI (E3)		2002-2003 HI (E4)		2002-2003 LI (E5)		2004-2005 LI (E6)		Grand mean
	Mean	Ij	Mean	Ij	Mean	Ij	Mean	Ij	Mean	Ij	Mean	Ij	
Plant height (cm)	41.00	2.18	40.72	1.90	46.31	7.49	38.08	-0.74	32.27	-6.56	34.56	-4.27	38.82
Branch number	6.29	0.42	6.00	0.12	5.56	-0.31	5.96	0.08	6.00	0.12	5.43	-0.44	5.87
Days to flowering	54.43	-1.77	53.67	-2.54	53.79	-2.42	61.88	5.67	53.66	-2.55	59.81	3.61	56.21
Pod number	26.81	4.23	26.60	4.03	26.32	3.75	17.69	-4.89	19.65	-2.92	18.37	-4.21	22.57
Pod length (cm)	7.09	0.16	7.16	0.23	7.23	0.30	6.10	-0.83	7.23	0.30	6.78	-0.15	6.93
Seeds per pod	11.48	0.70	11.11	0.34	10.75	-0.03	10.70	-0.08	11.31	0.53	9.30	-1.47	10.77
Test weight (g)	10.98	-0.15	11.26	0.13	11.37	0.24	11.65	0.52	11.23	0.10	10.30	-0.83	11.13
Husk weight (g)	2.22	0.31	2.31	0.40	2.23	0.31	1.51	-0.40	1.75	-0.17	1.46	-0.45	1.91
Stem weight (g)	3.71	0.28	3.77	0.33	3.91	0.48	3.26	-0.17	3.36	-0.08	2.60	-0.84	3.43
Harvest index (%)	35.82	2.90	34.80	1.88	33.18	0.26	31.29	-1.63	-	-	29.51	-3.41	32.92
Seed yield (g)	3.29	0.65	3.25	0.60	3.07	0.42	2.21	-0.44	2.35	-0.30	1.73	-0.92	2.65

HI, High input; LI, low input; E, environment.

improvement of a crop is the study of genetic variability and heritability in the available germplasm, the estimates of which are frequently subjected to environmental changes (Goswami, 2011). Therefore, the present investigation was undertaken to study genetic variability and heritability in fenugreek grown under six environments.

MATERIALS AND METHODS

Thirty diverse genotypes of fenugreek, collected from different parts of India, were grown during winter season for three consecutive years from 2002-2003 to 2004-2005 at the Agricultural Farm of Institute of Agriculture, Visva-Bharati University, India. The farm is situated under sub-humid, subtropical, lateritic belt of West Bengal, India at 23º39′ N latitude and 87º42′ E longitude with an average altitude of 58.9 masl. In each season, the crop was grown under two different [high input (HI) and low input (LI)] environments, created by changing the date of sowing, spacing, fertilizer dose and other crop management practices. In case of high input environment, date of sowing was 1st week of November with the spacing of 25 × 7.5 cm, fertilizer dose of 30:60:60 kg ha^{-1} and need based crop management practices like proper time of thinning, weeding, hoeing, irrigation etc. were adopted. However, in case of low input environment, date of sowing was 15 days later than that of HI environment with the spacing of 20 × 5 cm, fertilizer dose of 20:40:40 kg ha^{-1} and overall crop management practices were poor. In each environmental situation, the genotypes were grown in a randomized block design with 3 replications. Each plot consisted of 6 rows of 3-meter length. Data were recorded on 5 randomly selected plants from middle rows for 11 quantitative characters *viz*., plant height, branch number, days to flowering, pod number, pod length, seeds per pod, test weight, husk weight, stem weight, harvest index and seed yield for analyzing phenotypic and genotypic coefficients of variability (Burton, 1952) and heritability (Johnson et al., 1955).

RESULTS AND DISCUSSION

Analysis of variance revealed that mean squares due to genotypes were significant for all the characters in all the six environments, except harvest index in low input environment of 2002-2003 (designated as Environment 5). Therefore, harvest index in this environment was excluded from further genetic studies.

Based on mean performance and environmental index for all the characters, environments were arranged in descending order from rich to poor (Table 1). High input environment of 2003-2004 gave the highest overall performance among the six environments and hence was classified as the rich environment and was designated as Environment 1 (E1). The overall performance in high input environment of 2004-2005 and low input environment of 2003-2004 were lower than Environment 1 and were designated as Environment 2 (E2) and Environment 3 (E3), respectively. Further, low input environment of 2004-2005 produced lowest overall performance, which might be due to frequent showers at the later stages of crop growth and hence was classified as the poor environment and was designated as Environment 6 (E6). However, both high and low input environments of 2002-2003 also gave lower overall performance due to showers with hail storm at the time of flowering and resulted in poor seed yield with blackish colouration of seeds. These were designated as Environment 4 (E4) and Environment 5 (E5), respectively. Variation in performance due to different dates of sowing at Hisar was recorded for higher number of branches, pod number, test weight, seed yield and straw yield (Sheoran et al., 1999). Decrease in biomass production with increasing water stress (Kumari et al., 1999) and decrease in yield components with delayed sowing have been reported in two years trials with 5 dates of sowing at Jaipur, Rajasthan (Siyag and Bhardwaj, 2002a, b)

The estimates of genotypic and phenotypic co-efficient of variations (GCV and PCV) in all six environments (Table 2) revealed that plant height and test weight had

Table 2. Genotypic and phenotypic co-efficients of variation (GCV and PCV).

Character		Environments					
		E1	E2	E3	E4	E5	E6
Plant height	G	13.65	13.34	13.26	13.91	15.71	15.29
	P	17.33	15.40	14.52	16.53	19.60	17.45
Branch number	G	45.76	45.12	48.80	22.39	38.26	38.89
	P	48.00	47.75	50.15	27.68	42.01	41.71
Days to flowering	G	13.13	13.48	14.03	7.45	13.48	4.15
	P	13.23	13.56	14.08	7.63	13.56	4.69
Pod number	G	20.73	21.51	25.48	21.56	29.13	28.94
	P	23.91	25.29	28.02	26.70	35.57	33.14
Pod length	G	8.22	7.95	5.25	7.98	9.26	11.76
	P	9.61	9.40	6.48	14.11	11.18	13.53
Seeds per pod	G	7.95	13.17	11.08	19.69	14.42	16.96
	P	9.61	14.26	12.16	23.19	15.79	19.42
Test weight	G	12.33	13.95	11.76	17.19	13.92	13.57
	P	13.49	15.49	12.50	18.43	15.74	15.13
Husk weight	G	16.34	20.96	24.05	32.90	24.47	27.02
	P	29.58	33.02	30.95	46.41	39.79	36.09
Straw weight	G	21.13	21.44	16.27	22.13	29.57	28.83
	P	25.50	26.71	24.10	32.49	39.88	36.34
Harvest index	G	2.92	4.54	6.19	10.22	-	7.85
	P	6.45	7.31	10.67	14.09	-	13.87
Seed yield	G	19.53	24.61	24.96	32.97	32.15	34.78
	P	23.60	28.96	28.71	40.04	38.98	41.33

moderate GCV and PCV values (10-20%) in all the environments whereas, branch number, pod number, husk weight, stem weight and seed yield showed high estimates of GCV and PCV values (>20%) in all the environments, except moderate GCV values for husk weight and seed yield in E1. Moderate GCV and PCV for plant height, days to flowering, harvest index and test weight (Banerjee and Kole, 2004); high GCV and PCV values for branch number and pod number (Sharma et al., 1990; Kole and Mishra, 2006), pod weight and husk weight (Kole and Mishra, 2006), stem weight and seed yield (Sharma et al., 1990; Saha and Kole, 2001); and moderate GCV values for husk weight (Kole and Mishra, 2006) and seed yield (Banerjee and Kole, 2004) have been reported.

In case of days to flowering, GCV and PCV values were low (< 10%) in E4 and E6 while in other environments moderate values were recorded. GCV and PCV values for days to flowering have earlier been reported to be low (Sharma et al., 1990; Saha and Kole, 2001) or moderate (Banerjee and Kole, 2004).

In case of pod length, GCV and PCV values were low in E1, E2, E3 and moderate in E6 while low GCV and moderate PCV were observed in this character in E4 and E5. GCV and PCV for pod length were low (Dash and Kole, 2001; Saha and Kole, 2001; Banerjee and Kole, 2004) and moderate (Kole and Tiwari, 2006). Seeds per pod gave moderate GCV and PCV values in all the environments except low values in E1. Similar results for moderate (Kole and Mishra, 2006; Kole and Tiwari, 2006) and low values of GCV and PCV (Dash and Kole, 2001) for this character have been reported.

In case of harvest index, GCV and PCV values were low in E1, E2 and moderate in E4, whereas low GCV and moderate PCV values were noticed in E3, E5 and E6. GCV and PCV values for harvest index were reported to be low (Dash and Kole, 2001; Kole and Mishra, 2006) or moderate (Saha and Kole, 2001; Kole and Tiwari, 2006). GCV and PCV values in all the environments were moderate for plant height and test weight, and high for

Table 3. Estimates of heritability for eleven characters in six environments.

Character	E1	E2	E3	E4	E5	E6
Plant height	62.0	75.1	83.3	70.9	64.3	76.8
Branch number	90.9	89.3	94.7	65.4	82.9	87.0
Days to flowering	98.4	98.8	99.2	95.4	98.9	78.2
Pod number	75.2	72.4	82.7	65.2	67.1	76.3
Pod length	73.2	71.5	65.8	32.0	68.6	75.6
Seeds per pod	68.5	85.2	83.0	72.1	83.4	76.3
Test weight	83.5	81.0	88.5	87.0	78.2	80.5
Husk weight	30.5	40.3	60.3	50.3	37.8	56.0
Straw weight	63.6	64.4	45.6	46.4	55.0	63.0
Harvest index	20.5	37.9	33.6	52.7	-	32.0
Seed yield	68.5	72.2	75.6	67.8	68.0	70.8

branch number, pod number, husk weight, stem weight and seed yield indicating little influence of the environments on the estimates of these two genetic parameters. On the other hand, days to flowering, pod length, seeds per pod and harvest index showed changes in GCV and PCV values with the changes in environments.

Heritability values were categorized as low (< 50%), moderate (50-75%) and high (>75%). Accordingly, days to flowering, test weight, branch number and seeds per pod had high estimates of heritability (Table 3) in all the six environments, except moderate heritability for branch number in E4 and seeds per pod in E1 and E4.

High estimates of heritability for days to flowering and test weight (Saha and Kole, 2001; Banerjee and Kole, 2004), branch number (Kole and Tiwari, 2006) and seeds per pod (Dash and Kole, 2001) have been reported. Moderate estimates of heritability for branch number (Sharma et al., 1990; Saha and Kole, 2001; Banerjee and Kole, 2004) and seeds per pod (Saha and Kole, 2001; Kole and Tiwari, 2006) have earlier been reported.

Seed yield and pod length had moderate estimates of heritability in all the six environments except low heritability for pod length in E4. Moderate estimates of heritability have been reported for seed yield (Kole and Tiwari, 2006) and pod length (Sharma et al., 1990; Saha and Kole, 2001; Kole and Tiwari, 2006). However, low heritability for pod length was reported by Banerjee and Kole (2004). Plant height and pod number exhibited moderate heritability in all environments except high heritability in E3 and E6. Moderate estimates of heritability have been recorded for plant height (Sharma et al., 1990; Dash and Kole, 2001) and pod number (Chandra et al., 2000; Kole and Tiwari, 2006). However, high heritability for plant height (Banerjee and Kole, 2004) and pod number (Dash and Kole, 2001) has been reported.

Harvest index had low estimates of heritability in E1, E2, E3 and E6, and moderate heritability in E4. Low heritability has been reported by Garai (2006) while Kole and Tiwari (2006) recorded moderate heritability for harvest index. Stem weight and husk weight exhibited low to moderate heritability values. Low heritability for stem weight (Dash and Kole, 2001; Banerjee and Kole, 2004) and moderate heritability for husk weight (Kole and Mishra, 2006; Kole and Tiwari, 2006) have been reported earlier.

Pattern of consistency in heritability estimates over the six environments revealed that days to flowering and test weight having high heritability were less influenced by environment, pod length and seed yield having moderate heritability were moderately influenced by environment, and harvest index having low heritability was highly influenced by environment. For the rest of the characters, environments exerted variable effects.

Estimates of heritability were more or less same in E1 and E2 while it changed from high to moderate for plant height, branch number, pod number and seeds per pod and from moderate to low for pod length, husk weight, stem weight and harvest index in other environments. This indicated that E1 and E2 exerted almost similar environmental effects on the genetic expression of the characters, which was supported by almost similar environmental indexes of E1 and E2 for different characters. Changes in heritability in the other four environments might be due to variable environmental effects on the expression of the characters.

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