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Stability Analysis for Yield and its Component Traits in Fenugreek under Different Planting Dates in Fenugreek (*Trigonella foenum-graecum* L.)

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Abstract Sixteen indigenous genotypes of fenugreek were evaluated for stability with respect to days to 50% flowering, plant height, branches per plant, pods per plant, pod length, seeds per pod, seed yield/ha in five consecutive environments created by sowing on different dates in *rabi* 2012-13. The analysis of pooled data indicated highly significant differences among the genotypes and environments for all the traits. The variance due to genotype and environments were highly significant for all the traits.Highly significant pooled deviation for all the characters and linear component of G × E was significant only for plant height and seed yield per hectare suggesting that prediction of performance of genotypes was possible across the environments for these characters. Considering the stability parameters of individual genotypes, it is revealed that the genotype HM-348 has shown consistent performance and stability in wider environments for seed yield per hectare, whereas HM-346 had shown consistent performance in poor environment for seed yield per hectare and these genotypes can be utilized in further breeding improvement programs.

Keywords Fenugreek, Stability, Sustainability index, *Trigonella* sp., Yield.

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Introduction

Fenugreek commonly known as methi is one of the most important seed spice of India grown in an area of about 45000 ha producing 55780 tonnes of grain with a productivity of 1240 kg/ha. India is the largest producer of fenugreek in the world, where it is cultivated mainly in Rajasthan, Gujarat, Uttarakhand, Uttar Pradesh, Madhya Pradesh, Maharashtra, Haryana and Punjab. It is rich source of minerals, protein, vitamin A and C. Due to its multipurpose use, cultivation is increasing in the non-traditional areas of the country. The fermers of different states grow the landraces available with them. Since, there are very few varieties and majority of them were developed from available germplasm, the performance of fenugreek germplasm at different environments is of great importance in respect of screening them for stability, sustainability as well as for possibility of cultivation on non-conventional are as including unfavorable environments. The relative ranking and values of different genotypes varies with environments and a variety may achieve stability through individual buffering or population buffering. The genotype × environment interaction plays an important role in the ex-

Table 1. Pooled analysis of variance of traits for stability in fenugreek (Eberhart and Russell, *, ** = Significant at p = 0.05 and p = 0.01 levels, respectively, *PD=pooled deviation, PE= pooled error.

Source of variation	Df	Mean square Days to 50% flowering	Plant height (cm)	Branches per plant	Pods per plant	Seeds per pod	Seed yield (q/ha)
Genotype (G)	15	2.5*	61.5**	1.6*	88.8**	0.8	1.03**
Environment (E)	5	11.4**	32.8**	50.0**	47.5**	7.6**	39.2**
G × E	75	1.9	25.1	1.6**	69.1	0.8	1.0*
Environment (Linear)	1	57.0**	164.1**	250.0**	237.5**	37.8**	196.0**
G × E (Linear)	15	1.6	31	1.7*	60.2*	0.5	0.8*
PD*	64	1.9**	22.2**	1.4*	66.9**	0.8**	1.0**
PE*	180	1.74	19.63	0.99	70.7	0.69	0.72

pression of various plant characters. It is therefore, necessary to characterize the linear response of genotype to varying environmental conditions. The present study was undertaken to estimate G × E interaction and identifying stable genotypes under varying environments.

Materials and Methods

The experimental materials comprising of sixteen indigenous accessions which were grown during *rabi* (October to April) 2012-13 at CCS HAU, Hisar, which is located at latitude of 29^0 15´ North, longitude of 75^0 69´ East and at an altitude of 215.2 meter above sea level. The experiment was laid in randomized block design with three replications in five different environments i.e. E1 (16th October 2012), E2 (1st November 2012), E3 (16th November 2012), E4 (1st December 2012) and E5 (16th December 2012). Each plot was of 2.4 × 3.0 m size and accommodated eight 3.0 m long rows spaced 30 cm apart with plant to plant distance of 10 cm. The observations were recorded on days to 50% flowering, plant height (cm), number of primary branches, number of pods per plant, number of seeds per pod and yield per hectare (q). The data were analyzed statistically for stability parameters based on model [1]. The sustainability indices (SI) were estimated as per the following formula used by earlier workers [2].

$$SI = Y - \sigma_n / Y_m \times 100$$

Where, Y = Average performance of the genotype, σ_n = Standard deviation and, Y_m = Best performance of the genotype in any year/location.

The sustainability index were divided into five groups, viz., very low (up to 20%), low (21-40%), moderate (41-60%), high (61-80%) and very high (above 80%).

Results and Discussion

The pooled analysis of variance was carried out as per Eberhart and Russell model to determine the differences among genotypes, environments and genotype × environment interaction. The stability analysis of variance mean data (Table 1) revealed significant differences among the genotypes as well as environments for all the traits indicating the presence of considerable amount of variability both genetically and environmentally. Genotype × Environment (G × E) interaction was studied for seed yield per hectare and its component characters, i.e. days to 50% flowering, plant height,number of primary branches per plant, pods per plant, seeds per pod (Table 2). G × E interactions were highly significant for plant height and seed yield per hectare. Similar observations have been reported earlier [3, 4] in fenugreek. Highly significant mean squares due to environment (linear) for all the traits indicated considerable differences among the environments and their predominant effects on the traits. This was due to variation in climatic conditions during date of sowing. Highly significant pooled deviations for all the characters indicated non linear response of the genotypes due to environmental changes and greater role of unpredictable components of G × E interaction towards differences in stability of the genotypes. It is reported that both predictable and unpredictable components contributed significantly towards the differences in stability of

Table 2. Estimates of stability parameters for days to 50% flowering plant height and branches per plant in sixteen genotypes of fenugreek. *, ** = Significant at p = 0.05 and p = 0.01levels, respectively.

	Days to 50% flowering				Plant height (cm)				Branches per plant			
Genotype	Mean	b_i	S^2d_i	*SI*	Mean	b_i	S^2d_i	*SI*	Mean	b_i	S^2d_i	*SI*
FGK-30	53.83	2.03	0.92	94.67	73.34	1.05	15.35	71.44	7.46	1.13	0.57	59.87
HM-57	54.50	-0.40*	0.65	98.14	71.48	0.89	9.74	80.47	8.16	1.2	2.50*	63.84
HM-103	54.61	0.83	0.78	96.57	70.08	0.88	65.64*	69.63	7.67	1.08	2.06*	65.39
HM-219	34.72	0.52	1.15	95.76	76.66	1.1	3.03	74.33	8.17	1.2	-0.15	65.35
HM-355	54.56	0.72	1.72*	94.76	72.74	1.01	-3.15	78.14	6.66	0.72	-0.07	68.27
HM-273	55.28	1.54	1.45	96.54	78.86	1.21	8.37	72.16	6.79	0.36	2.04*	76.3
HM-273-1	35.78	0.91	0.84	96.89	71.37	1.06	15.78	75.15	7	0.49	0.72*	64.93
HM-291	56.28	1.76	0.19	95.76	72.76	1.05	1.97	73.75	7.34	1.46	2.06*	51.7
HM-293-1	55.28	0.82	1.74*	96.78	79.11	1.11	-0.14	76.27	7.73	1.26	1.38*	53.92
HM-346	55.44	1.19	0.42	95.06	24.31	0.81	-1.07	81.03	7.72	1.18	1.20*	66.86
HM-348	54.67	0.92	4.56*	94.61	79.89	1.06	37.62*	74.46	7.33	0.81	0.03	69.8
HM-257	55.83	0.36	0.90	96.39	69.28	0.76	28.80*	27.97	6.59	0.75	1.43*	68.31
HM-444	55.83	0.53	1.83*	95.12	74.1	1.34*	17.98	74.09	7.78	1.46	0.2	57.15
PEB	55.44	0.73	-0.24	95.55	72.39	0.72	-3.43	81.66	8.08	1.19	1.16*	62.23
Rmt-1	55.28	2.30	0.38	93.99	75.42	0.81	17.92	76.16	6.86	0.68	-0.12	74.03
Rmt-361	55.44	1.26	2.98*	96.76	75.98	1.15	35.69*	69.1	7.53	1.02	2.17*	60.82
P. mean	55.17	1.00			74.24	1.0			7.43	1.0		
SEd	0.61	0.72			2.11	0.14			0.54	0.3		

fenugreek genotypes [5]. However, prediction for unpredictable traits can be made by considering the stability parameters of individual genotypes. This also suggested that the prediction for these characters would be perfect.

According to Eberhart and Russell's criteria of stability, a stable genotype should have higher mean than population mean, regression coefficient (b_i) near unity and deviation from regression (S^2di) near 0. The stability analysis for seed yield revealed that ten out

Table 3. Estimates of stability parameters for pods per plant, seeds per pod and seed yield/ha in sixteen genotypes of fenugreek. *, ** = Significant at p = 0.05 and p =0.01 levels, respectively.

	Pods per plant				Seeds per pod				Seed yield (q/ha)			
Genotype	Mean	b_i	S^2d_i	*SI*	Mean	b_i	S^2d^i	*SI*	Mean	b_i	S^2d_i	*SI*
PGK-30	68.03	1.02	20.03	46.47	12.03	0.92	0.16	55.63	15.36	0.93	0.32	52.19
HM-57	62.62	0.73	107.69*	70.12	12.12	1.7	0.68*	78.47	15.03	1.06	0.71*	85.32
HM-103	62.58	1.05	15.75	64.78	12.18	0.13	-0.11	96.34	14.87	0.97*	0.08	86
HM-219	65.38	1.19	-13.62	61.28	11.57	1.19	0.25	86.76	15.03	1.33	0.13	79.41
HM-355	54.94	0.76	17.96	64.93	12.01	1.67	0.22	63.74	14.33	0.79	0.15	87.2
HM-273	61.27	0.79	55.82*	64.53	11.4	1.33	0.46	87.04	14.61	1.11	0.33	86.11
HM-273-1	60.92	0.7	143.85*	79.25	12.46	0.61	2.72*	85.63	14.76	1.19	0.01	73.75
HM-291	60.92	1.02	15.67	60.55	12.1	1.21	-0.15	89.75	14.76	1.06	2.42*	85.8
HM-293-1	66.4	1.36	-14.6	57.67	11.22	0.94	-0.06	88.95	15.37	0.85	1.43*	87.83
HM-346	68.03	1.02	178.75*	71.06	12.11	0.54	2.14*	80.5	14.86	0.43*	2.10	88.85
HM-348	62.62	0.73	39.89	58.61	11.61	0.38	0.01	94.6	15.43	1.04	0.46	85.97
HM-257	62.58	1.05	0.65	67.39	11.47	1.32	1.15*	85.58	14.42	1.01	0.87*	86.02
HM-444	65.38	1.19	29.1	59.12	11.63	0.69	0.68*	86.94	14.89	0.95	2.25*	85.6
PEB	54.94	0.76	88.58*	55.55	11.32	0.94	-0.14	91.05	15.03	0.75	-0.16	90.16
Rmt-1	61.27	0.79	-9.99	69.99	11.74	1.22	0.3	85.92	14.77	0.99	0.2	85.32
Rmt-361	60.92	0.7	18.67	67.76	11.93	1.23	1.12*	84.84	14.88	1.58*	0.82*	74.12
P. mean	63.04	1.0			11.81	1.0			14.81	1.0		
SEd	3.66	0.21			0.3	0.58			0.26	0.33		

of sixteen genotypes had stable and predictable performance on account of non significant deviation for regression (Table 3). Four genotypes namely FGK-30, HM-219, HM-348 and PEB recorded high mean, non-significant deviation from regression and regression coefficient were found stable and suitable for wider adaptability. HM-346 recorded higher mean, significant regression coefficient value less than I and non significant deviation from regression; hence found stable for unfavorable environment and HM-103 recorded higher mean, significant positive regression coefficient along with non significant deviation from regression indicating stability and suitability for favorable environment. With respect to plant height, genotypes HM-219, HM-293-1, HM-273 and RMt-1 were found suitable for wider adaptability and HM-444 for favorable environment [6]. Three genotypes namely FGK-30, HM-219 and HM-444 with more branches per plant than population mean, non significant regression co-efficient and deviation from regression were found stable and suitable for wider environments. In case of pods per plant, FGK-30, HM-219, HM-293-1 and HM-444 possessed higher pods per plant than population mean were stable and suitable for wider adaptability with non significant regression co-efficient and deviation from regression [7]. Further for seeds per pod, FGK-30, HM-103, HM-355 and HM-291 higher seeds per pod than population mean with non significant regression co-efficient and deviation from regression, stable and suitable for wider adaptability. Similar results have been reported earlier [8].

It was reported that generalization regarding stability of a variety for all the descriptors is rather difficult. In the present investigations also, genotypes did not show uniform stability and linear response pattern for all the traits. However, the overall stability may be considered on the basis of compensation pattern of different traits. For seed yield per hectare the sustainability index (SI) for all the genotypes ranged from 52.19% to 90.16%. Among the four genotypes which are identified suitable for wider adaptability, three genotypes namely, HM-219, HM-348 and PEB showed high SI, thus indicating that the genotypes would give better performance consistently over the diverse environments. HM-346 which showed suitability for unfavorable environment on the basis of stability parameters recorded very high SI, indicating consistent performance in unfavorable environments. For plant height, among the four genotypes identified suitable for wider adaptability, all the genotypes showed high SI and genotype HM-444 identified for favorable environment also showed high SI. In case of pods per plant, genotypes suitable for wider adaptability showed moderate SI except HM-219, thus indicating average performance over the years.

Conclusion

On the basis of above findings, it can be concluded that HM-348 has shown promising and consistent performance in wider environments for seed yield per hectare number of branches per plant and seeds per pod whereas the genotype HM-346 has shown promising and consistent performance in poor environment for seed yield per hectare and that these genotypes could be grown for better yield performance in the indicated environment.

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