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Stability analysis for yield and yield attributes in fenugreek under water limiting conditions (*Trigonella foenum-graecum* L.)

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Abstract

Thirteen genotypes of fenugreek (*Trigonella foenum-graecum* L.) were evaluated over three environments during *rabi* 2012-13 in Randomized Block Design with 3 replications to estimate stability parameters for days to 50 per cent flowering, plant height, branches per plant, days of 75 % pod maturity, number of pods per plant, pod length, number of seeds per pod, test weight, biological yield and seed yield per plant. Environment wise analysis of variance was significant for all the traits in all the environments. Genotype x environment interaction was significant for all the characters. Environment + (variety x environment) component was significant for most of the traits *viz*., plant height, number of branches, days to 50 per cent flowering, number of pod per plant, biological yield and seed yield per plant. The pooled analysis was significant for all the traits except branches per plant, days of 50% flowering and days of 75% pod maturity. The environmental indices had wide differences for seed yield ranging for -2.053 in environment - I to 1.859 in environment - III as well as for other characters. The highest yielding variety was AFg-6 followed by AM-413 and AFg-3 among thirteen genotypes of the present study. Mean seed yield was linearly influenced by the environment it was lowest in the most unfavorable environment. The test weight and branches per plant was least affected by environment. Genotypes C-1-32-17 is found relatively stable therefore more suitable for seed yield. This may be used in further improvement programmes to generate stable genotypes. Genotype AFg-3, AFg-6 and AM-413 have below average stability for the seed yield for better environment. Genotype AFg-4, B-2-19 and AM-293 have above average stability for seed yield and suitable for poor environment.

Key words : Fenugreek, GxE interaction, stability, *Trigonella foenum-graecum,*

Introduction

Fenugreek (*Trigonella foenum-graecum* L.) is a self-pollinated crop. It occupies a prime position among various seed spices grown in India. It is an annual herb belonging to sub-family *Papilionaceae* of the family *Fabaceae*. The plant leaves and seeds are widely consumed in Indo-Pak subcontinent as well as in other oriental countries as a spice in food preparations, and as an ingredient in traditional medicine. Seeds are used as condiments and for flavoring food preparation. It is aromatic, carminative, tonic and abscesses ulcers and internally as emollient for inflammation of intestinal tract (Rathore *et al.,* 5, Meena *et al., 6*). Its tender leaves are consumed as leafy vegetable, chopped leaves are mixed in flour to prepare “parantha”. In addition to this it serves as a soil renovating crop. Being a legume, its roots are endowed with root nodules containing “Rhizobium” which fix atmospheric nitrogen for plant, thus, its cultivation enriches the soil with nitrogen. The seeds contain important steroid, diosgenin which is used in preparation of contraceptives. Fenugreek is mainly cultivated in India, Argentina, Egypt, Morocco, Southern France, Algeria, Ethiopia and Lebanon (Bose *et al*., 2). In India it is mainly cultivated in the state of Rajasthan, Gujrata, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, Himachal Pradesh, Madhya Pradesh and Haryana covering an area 93090 ha with an annual production and productivity of 112845 tonnes and 1212.2 kg/ha, respectively a per advance estimates for the year 2012-13 (Anonymous, 1).

Fenugreek is having an high influence of environment on the morpho-physiological expression, therefore an evaluation of germplasm under different environment to ascertain the real potential of the genotype (Toshniwal, 9) is necessary. Information on seed and forage yield of fenugreek line is extremely limited. Hence, this study was conducted to elucidate the effect of G, E, and G x E on seed yield of newly identified fenugreek lines, by quantifying their individual contribution to yield variance.

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Material and methods

Thirteen advance genotypes of fenugreek were used for this study. The experiment was laid out in randomized block design with three replications in each three environments. Thirteen genotypes were randomly allotted in each replication using random number during *rabi* 2012-13. Three environments were created artificially by providing controlled irrigation viz. Midterm water stress environment, Terminal water stress environment and Non water stress environment. The plot size was 3 x 2 m and crop geometry was 50 x 5 cm. Observations were recorded for plant height, days to 50 per cent flowering, number of branches per plant, days of 75 per cent maturity, number of pods plant^{-1}, number of seeds pod^{-1}, pod length, 1000-seed weight, biological yield plant^{-1} and seed yield plant^{-1}.

The data on each character were subjected to standard statistical analysis of variance for each environment separately (Panse and Sukhatme, 7). Later the data of each were subjected to pooled analysis of variance (Singh and Choudhary, 8). Further, stability analysis was carried out according to Eberhart and Russell (3).

Result and discussion

Analysis of variance for each character was done in each environment to know the differences in the genotypes. Significant difference between genotypes were observed for all the characters namely, plant height, branches plant^{-1}, days to 50 per cent flowering, days of 75 per cent pod maturity, number of pods plant^{-1}, number of seeds pod^{-1}, pod length, test weight, biological yield and seed yield plant^{-1} in each environment. It indicates that the genotypic differences are real and expressed in all the environments. The pooled analysis of variance for genotype x environment interaction revealed significant differences among varieties for all the characters except number of branches and biological yield. The environmental effects were also highly significant for all the characters except number of branches per plant, pod length and test weight. While variety x environment interaction was significant for all the characters, it indicated the differential influence of environment on the expression of genotypes to the most of the characters including seed yield (Table 1).

Grading of Environments

The environment can be graded based upon the overall mean performance of the variety (Finlay and Wilkinson 4). Thus, an environmental index (which is the difference between the mean of characters at the environment in question and the grand mean) has been calculated for all the characters and all the environments. It is observed that suitable environment in the present case, was different for different characters (Table 2). For test weight the most favorable environment is environment-I (Midterm stress environment), the least favorable is environment-II (Terminal stress environment). For other characters namely plant height, number of branches, days of 50 per cent flowering, Days of 75 per cent pod maturity, pods plant^{-1}, number of seeds pod^{-1}, pods length and seed yield the most favorable environment is environment-III (Non stress environment).

Joint Regression Analysis of Variance

Stability analysis by joint regression analysis (Eberhart and Russell 3) revealed that the linear component of G x E interaction was highly significant for number of branches and days to 50 % flowering indicating that genotypes had divergent linear response to the environmental changes for number of branches and days to 50 % flowering (Table 3). The G x E (linear) was not significant for remaining characters indicating that variation in the performance of genotypes was predictable. Similar response was also obtained by Toshniwal (8) for plant height, pods plant^{-1}, grain pod^{-1} and test weight in fenugreek. The pooled deviation were also significant for all the traits except number of branches, days of 50 % flowering and days of 75 % pod maturity (Table 3) suggesting that deviations from linear regression also contributed substantially to the differences in stability of the genotypes for these characters. Therefore, indicating non-predictable performance of genotypes across to environments. It may be concluded that for seed yield both linear as well as non-linear components were highly significant indicating that the both predictable and unpredictable components contributed significantly, towards the differences in stability among different genotypes.

Stability Parameters

Stability parameters were calculated for biological yield and seed yield per plant (Table 4). The mean biological yield ranged from 12.32 (AM-327) to 23.74 (B-2-19) with general mean 19.12. The environmental indices ranged from 13.55 to 23.78 indicating wide differences among the environments. The regression coefficient ranged from -0.090 (AM-292) to 1.998 (AFg-6). The S^2d estimates for genotypes RMt-305, AM-327, AM-292, B-2-19, AM-293 and AFg-5 was at zero but other genotypes S^2d deviated significantly from zero. The genotype AFg-5 ($\overline{X}$ = 19.58 βi = 0.86 and S^2d = -1.05), AM-293 ($\overline{X}$ = 21.68 βi = 0.90 and S^2d = -1.63) and (B-2-19 ($\overline{X}$ 23.74 βi = 0.88 and S^2d = -1.51), had high mean than general mean, regression coefficient was equal to 1 with non-significant S^2d value, so these genotypes are most stable for biological yield. AFg-5, AM-293 and B-2-19 considered being most desirable genotypes because these genotypes had high mean than general mean and regression coefficient near about unity. It is interesting to note that all the genotypes having high mean were found suitable for better

Table 1. ANOVA (Pooled) for G x E integration for different characters in fenugreek

	Df.	Mean sum of squares									
		Plant Height	No. of branches	Day of 50% flowering	75% of pod maturity	No. of pod per plant	No. of seeds per pod	Pod length	Test weight	Biological yield	Seed yield per plant
Rep. within Env.	6	7.34252	0.6264	1.49288*	3.73219**	178.63131**	0.63453	0.42049	0.07385	3.836	0.30664
Varieties	12	132.73805**	0.07898	52.02136**	2.37322*	182.39741**	3.26420*	8.22967**	16.27560**	35.83207	6.91621*
Environments	2	610.81475**	0.19026	30.04603**	13.34997**	1271.04339**	5.18484*	1.47701	5.48744	348.38284**	50.09342**
Var.*Env.	24	10.5708**	0.11985**	0.9437**	0.45232**	49.4139**	0.63579**	0.31299**	1.02362**	14.71432**	2.24569**
Pooled Error	72	0.65083	0.02771	0.4651	0.09022	5.35134	0.13726	0.03838	0.12138	1.45175	0.08599

* Significant at 5% levels

** Significant at 1% levels

Table 2. Environment at indices for different characters of fenugreek genotypes

Environments	Plant Height (cm)	No. of branches	Days of 50% flowering	Days of 75% pod maturity	No. of pod per plant	No. of seeds per pod	Pod length (cm)	Test weight (g)	Biological yield (g)	Seed yield per plant (g)
Environment-E1 (Midterm stress)	-7.731	-0.061	-1.752	-1.000	-8.899	-0.224	-0.316	0.750	-5.574	-2.053
EnvironmentE2 (Terminal stress)	2.395	-0.079	0.786	-0.026	-1.745	-0.486	-0.039	-0.402	0.917	0.194
EnvironmentE3 (Non stress)	5.366	0.139	0.966	1.026	10.644	0.713	0.355	-0.347	4.657	1.859
Grand mean	36.91	5.57	61.88	87.22	51.76	14.91	11.24	14.13	19.12	7.39

Table 3. ANOVA for joint regression analysis of variance Stability for all characters

	d.f.	Mean sum of squares									
		Plant Height (cm)	No. of branches	Days of 50% flowering	Days of 75% pod maturity	No. of pod per plant	No. of seeds per pod	Pod length (cm)	Test weight (g)	Biological yield (g)	Seed yield per plant (g)
Varieties	12	132.7380**	0.0789	52.0213**	2.3732*	182.3974**	3.2642*	8.2296**	16.2756**	35.8320	6.9162*
Env.+ (Var.*Env.)	26	56.7434**	0.1252*	3.1823**	1.4444	143.3854**	0.9857	0.4025	1.3670	40.3811*	5.9262*
Environments (Lin.)	1	1221.6295**	0.38052*	60.0920**	26.6999**	2542.0867**	10.3696**	2.9540	10.9748	696.7656**	100.1868**
Var.*Env. (Lin.)	12	13.5690	0.2021*	1.5916*	0.4252	74.6997	0.7046	0.1764	0.8761	18.1185	2.7771
Pooled Deviation	13	6.9900**	0.0346	0.2730	0.4425	22.2720**	0.5233**	0.4149**	1.0810**	10.4400**	1.5823**
Pooled Error	72	0.6508	0.0277	0.4651	0.0902	5.3513	0.1372	0.0383	0.1213	1.4517	0.0859
Total	38	80.7417	0.1106	18.6051	1.7377	155.705	1.7052	2.8742	6.0749	38.9445	6.2388

* Significant at 5% levels
** Significant at 1% levels

Table 4: Mean values and stability parameters (βi and S^2d) of the fenugreek genotypes for biological yield (g) and seed yield per plant (g)

Genotypes	Biological yield per plant (g)			Seed yield per plant (g)		
	Mean	βi	S^2di	Mean	βi	S^2di
A-1-1-2	13.62.44	1.01	1.5947	7.0411	1.57	4.9419***
AFg-6	22.8111	1.995	41.6154***	9.3122	1.932	1.8982***
AFg-3	19.6244	1.700	18.0978	7.7033	1.673	1.8943***
RMt-305	18.9911	1.382	-0.7107	7.0822	0.909	0.7648**
C-1-32-17	17.0644	0.361	27.2725***	7.41	0.894	0.2692
Hisar Sonali	17.8778	1.578	11.5902**	7.1089	1.567	2.8445***
AM-327	12.3222	0.578	0.5071	4.1522	0.262	2.2802
AM-292	22.6222	-0.090*	-1.6296	4.7567	.089*	-0.0918
AFg-4	17.4922	0.541	1.4264	7.5744	0.446	.6072*
AM-413	21.1667	1.37	18.8962***	8.8744	1.535	0.2689
B-2-19	23.7444	0.876	-1.5144	8.5378	0.573	-0.0369
AM-293	21.68	.900*	-1.6351	8.9967	0.566	1.9186***
AFg-5	19.5789	0.862	-1.0463	7.5378	0.983	2.6731***

*, **, *** = Significant at 5per cent and 1per cent levels and non significant, respectively

environments. AFg-3, AM-413 and AFg-6 had high biological yield than general mean and regression coefficient more than unity so they are suitable for better management conditions. AM-292 had high mean and less regression coefficient (βi = 1) so, these are suitable for poor management conditions.

The mean seed yield per plant ranged from 4.15 (AM-327) to 9.31 (AFg-6) with general mean 7.39. The environmental indices ranged from 5.34 to 9.25 indicating wide differences among the environments. The regression coefficient ranged from 0.09 (AM-292) to 1.93 (AFg-6). The S^2d estimates for genotypes RMt-305, C-1-32-17, AM-292, AFg-4, AM-413 and B-2-19 (Table 4.4.5) was at zero but other genotypes S^2d deviated significantly from zero. The genotype C-1-32-17 ($\overline{X}$ = 7.41 βi = 0.894 and S^2d =0.2692) had high mean than general mean, regression coefficient was equal to 1 with non-significant S^2d value, so this genotype is most stable for seed yield per plant. Genotype AFg-3 ($\overline{X}$ = 7.70, βi = 1.67 and S^2d = 1.89, AM-413 ($\overline{X}$ = 8.87, βi = 1.53 and S^2d = 0.27) and AFg-6 (x =9.3122, βi = 1.93 and S^2d = 1.90) are suitable for better environment. The genotype AFg-4 ($\overline{X}$ = 7.57, βi = 0.45 and S^2d = 0.61), B-2-19 ($\overline{X}$ = 8.54, βi = 0.57 and S^2d = -0.03) and AM-293 ($\overline{X}$ = 8.99, βi = 0.57 and S^2d = 1.92) are suitable for poor environment as these genotypes have better mean than general mean and lesser regression coefficient thus, exhibiting above average stability. It is interesting to note that all the genotypes having high mean were found suitable for better environments. AFg-3, AM-413 and AFg-6 had high seed yield than general mean and regression coefficient more than unity so they are suitable for better management conditions. AFg-4, B-2-19 and AM-293 had high mean and less regression coefficient (βi = 1) so, these are suitable for poor management conditions.

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