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Comparing stability of snap bean genotypes

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ABSTRACT

Six new Snap bean varieties viz.,'HAFB-3', 'HAFB-4','DWD-FB-1','Arka Anoop','VLFB-2004' and 'VLFB-130' were evaluated for three years along with checks viz., 'IIHR-909' and 'Contender' during 2005, 2006 and 2007 to study the genotype-environment interaction and stability for growth and yield traits at the University of Agricultural Sciences, Dharwad, Karnataka. The varieties were sown in randomized block design with three replication within each season. Considerable amount of variability was noticed among the genotypes as there was a significant varietal difference. Significant mean squares due to environments for many of the traits indicated that the environments were different. Similarly, G X E (linear) were non-significant for many of the traits except average pod weight indicating that the genotypes responded similarly as the environments changes. And, the magnitude of regression coefficient and deviation from regression varied from genotype to genotype. The genotypes 'DWD-FB-1' and 'HAFB-3' are stable for many of the traits and these are suitable to cultivate in *kharif* season.

Key words: Snap bean, *Phaseolus vulgaris* L., genotypes, environments, pod yield, stability and genotype x environment

INTRODUCTION

Snap bean or French bean (*Phaseolus vulgaris* L.) is one of the most important leguminous vegetable besides being the world's leading food legume. In India, it is grown for tender green pods, shelled beans and dry beans (rajmah). Beans crop may face several problems with change in rainfall distribution and other weather parameters as it is cultivated during rainy season in tropical and sub-tropical condition. The major objective of any vegetable crop improvement programme is to develop genotypes that perform well with consistency over the years. Hence, the present investigations were carried out to identify the consistency and stability of newly developed snap bean varieties developed by different institutions during *kharif* season with higher yield and other desirable traits. One of the major constraints in this objective is genotype x environment interaction which makes it difficult to correctly identify genotypes that could exhibit stable performance over the different environments (Comstock and Moll, 1).

MATERIAL AND METHODS

The experimental materials comprised of promising eight snap bean genotypes developed from different institutions across India *viz.*, 'HAFB-3' and 'HAFB-4' (HARP, Ranchi) 'DWD-FB-1' (UAS, Dharwad), 'VLFB-2004' and 'VLFB-130' (VPKAS, Almora, Uttaranchal), 'Arka Anoop' and 'IIHR-909' (IIHR, Bangaluru) and 'Contender' (Katrain). They were evaluated for three years (2005, 2006 and 2007) during *kharif* in a randomized block design with three replications at the All India Coordinated Vegetable Improvement Project at the Main Agriculture Research Station, University of Agricultural Sciences, Dharwad. The meteorological data i.e. rain fall, mean temperature and relative humidity of individual year is given in Table 1. The dates of sowing were 05.07.2005, 21.07.2006 and 04.07.2007 for three seasons. The rainfall received during 2005, 2006 and 2007 during cropping period was 1089.32, 608.38 and 917.30 mm respectively. The soil type was vertisols. Each genotype was raised in a net plot size of 3.6 x 3.0 m with a spacing of 40 cm x 20 cm from row to row and plant to plant respectively. All the recommended package of practices were followed for raising the crop. Observations were recorded from 10 randomly selected plants for plant height (cm), pod length (cm), pod girth (cm), number of pods per plant, green pod yield per plant (g), average pod weight (g) and green pod yield per plot (kg). Yield per hectare (t) is computed on the basis of plot yield. The data was analysed on the basis of mean performance over the years as per the model suggested by Eberhart and Russel (2) for various characters.

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Table 1. Meteorological data of 2005, 2006 and 2007 during the crop season.

Months		Rainfall (mm)			Mean temperature (°C)						Relative Humidity (%)					
					Maximum			Minimum			Maximum			Minimum		
		2005	2006	2007	2005	2006	2007	2005	2006	2007	2005	2006	2007	2005	2006	2007
June 01	June 15	50.40	40.80	50.10	33.23	29.38	32.27	21.95	20.27	21.83	86.07	88.93	88.93	48.93	61.00	55.20
June 16	June 30	100.60	171.60	170.00	28.68	29.64	27.17	21.12	20.90	20.88	91.80	91.67	92.27	77.40	72.27	82.40
July 01	July 15	260.20	90.00	159.00	33.80	26.80	26.35	19.00	20.68	21.51	73.25	93.67	91.07	32.93	80.20	80.40
July 16	July 31	210.40	5.38	52.60	27.17	26.33	29.41	20.87	20.16	22.07	94.76	93.19	96.33	78.99	82.81	83.53
Aug 01	Aug 15	66.40	83.40	132.20	26.03	25.00	25.77	20.67	19.86	20.52	92.13	94.33	93.53	82.13	86.87	81.87
Aug 16	Aug 31	72.40	31.80	43.80	28.11	27.59	28.27	20.09	19.39	20.44	92.19	91.31	90.25	71.63	70.13	71.88
Sept 01	Sept 15	107.80	37.20	39.80	27.91	31.44	27.45	20.82	19.87	20.47	94.33	84.01	93.20	75.53	51.98	76.13
Sept 16	Sept 30	86.70	54.20	141.00	26.99	27.84	26.96	19.78	20.11	20.23	91.67	89.33	91.33	77.40	71.20	73.53
Oct 01	Oct 15	28.40	37.40	4.00	30.14	29.03	30.33	19.58	19.93	19.54	86.40	87.80	76.25	56.33	61.87	60.31
Oct 16	Oct 31	3.81	1.20	70.80	29.86	30.97	29.08	18.44	18.29	19.32	78.75	80.00	77.25	55.88	44.44	60.31
Nov 01	Nov 15	102.81	35.80	54.00	29.56	28.71	30.19	15.15	17.77	16.90	69.53	86.90	74.00	35.13	54.33	41.13
Nov 16	Nov 30	00.00	19.60	00.00	29.33	29.71	28.87	14.59	18.59	13.17	65.07	86.80	62.40	35.27	52.00	34.60
Total		1089.92	608.38	917.30												

RESULTS AND DISCUSSION

The analysis of variance for the individual environment revealed significant differences for all the characters in all the three environments (2005, 2006 and 2007) indicating the existence of genetic differences among the snap bean varieties studied.

The mean sum of squares due to varieties were significant for most of the traits studied except days to 50% flowering and pod girth (cm) indicating considerable amount of variability among the genotypes studied (Table 2) similar results were reported by Pal and Krishna Prasad (7) and Perez-Barbeito *et al.* (8). Component analysis of environment + (genotype x environment) were significant for pod length and girth. Partitioning of this variation into linear and non-linear components revealed that the mean squares due to environment (linear) were significant for most of the characters except plant height, average pod weight, and yield per hectare. The significant mean squares confirm that the environments were different and they exercised influence on the expression of those traits and this variation could have arisen due to the linear response of the regression of the cultivar to the environments. The mean square due to G x E (L) was highly significant for average pod weight. It revealed that the behaviour of the genotypes could be predicted over the environments for this trait more precisely and accurately as the different genotypes responded differently to environments similar opinion was made by Nimbalkar *et al.* (6). Similarly, G x E (linear) were non-significant for many characters except average pod weight indicating that the genotypes responded similarly as the environments changes and absence of genetic difference among the genotypes for their regression on environment index making difficult the prediction for the performance of these traits. Same result was reported by Krishna Prasad *et al.* (4). In contrast to this Mechbib (5) reported significant genotype by environment interaction which indicated that the relative performance of the varieties altered in the different environments.

The non-linear component arising due to the heterogenity measured as mean square due to pooled deviation was non-significant for all the traits revealing presence of linear response of the genotypes to the changing environments. The genotypes differed with respect to the stability of the traits making its prediction more difficult. However, the magnitude of linear component i.e. environment (L) and G x E (L) was higher than the non-linear component (pooled deviation) for most of the characters revealing that the prediction of stability could be reliable. Comparison of G x E interaction with non-linear component revealed that it was insignificant for most of the traits except average pod weight. In traits

Table 2. Pooled ANOVA for growth and yield parameters in french beans.

Source of variation	d.f.	Days to 50% flowering	Plant height (cm)	Pod length (cm)	Pod girth (cm)	Average pod wt. (g)	No. of pods /plant	Green pod yield per plant (g)	Green pod yield (t/ha)
Varieties	7	1.81	29.12*	3.20*	0.01	4.32**	28.09*	1613.88*	4.28*
Env. + (Var. x Env.)	16	7.66	9.56	3.23*	0.05*	0.17	17.45	994.06	0.58
Environments	2	45.98**	6.7	11.33	0.35**	0.26**	69.58*	2567.07	0.10
Var. x Env.	14	2.18	10.05	2.07	0.01	0.15**	9.99	769.34	0.65
Env. (Linear)	1	91.96**	12.15	22.66**	0.70**	0.52	139.15**	5134.14**	0.20
Var. x Env. (Linear)	7	2.66	6.70	0.73	0.10	0.29**	5.90	387.23	0.93
Pooled deviation	8	1.49	11.73	2.99	0.01	0.01	12.34	1007.52	0.32
Pooled error	48	0.89	1.95	0.30	0.002	0.16	5.50	106.68	0.17

* Significant at 5% level and **significant at 1% level

where the non-linear component was non-significant, the G x E interaction for these traits was greatly influenced by environmental factors and there exist either no-relationship between genotype and environments effect making its prediction more difficult for that trait.

According to Eberhart and Russel (3) an ideal variety would be one that possessed high mean performance, unit regression coefficient (b_i=1) and least deviation from regression i.e. as far as possible equal to zero (S^2d_i=0). However, if a variety possessed negative regression coefficient then the variety should be suitable for poor/ unfavourable environments. When regression coefficients (b_i) were non-significant, S^2d_i became an important statistic in estimating stability. It appears that the regression coefficient, b_i, was best used to estimate genotypic adaptability, whereas, S^2d_i for stability.

The stability analysis for individual genotype for days to 50% flowering, the genotypes had b_i value non significant from units (b_i=1) except the genotypes 'HAFB-3' and 'IIHR-909' were significant (Table-3). This indicates average response of varieties across the environments. It was observed that all the genotypes except 'DWD-FB-1', 'VLFB-130', 'Arka Anoop' and 'HAFB-4' are stable as they are near to zero and negative S^2d_i value and also they are suitable for unfavorable environments. In case of plant height, the genotypes, 'DWD-FB-1', 'VLFB-130', and 'HAFB-3' had highest mean performance, whereas, 'DWD-FB-1' (0.10) and 'VLFB-2004' (-3.02) shows negative regression coefficient. Thus, these genotypes are stable for poor environments. Other genotypes exhibit more than one b_i values which indicates better adaption to favourable environment.

The long pods are desirable. The genotypes 'DWD-FB-1', and 'Arka Anoop' recorded highest mean for pod length over the environments (Table 3). The genotypes 'DWD-FB-1', 'VLFB-130', and 'HAFB-3' and 'Contender' had b_i value significantly lower than 1, indicating better adaption even to unfavourable environment. Except 'VLFB-2004' (0.04) S^2d_i value which is only near to zero indicates that it is stable and others with average response to the environments. Regarding pod girth, the variety 'DWD-FB-1' had least mean over the environments (0.65 cm). It indicates that the variety is long, thin and attractive poded during the tender stage. Highly significant b_i value along with near zero S^2d_i value recorded by this variety indicates it's stability for differential environments for this trait.

For average pod weight, the genotypes exhibit b_i values which were non-significant from unity and they showed an average response over the environments (Table 3). Regression coefficient (b_i) values of 'DWD-FB-1', 'Arka Anoop', 'IIHR-909' and 'Contender' are higher than unity. Thus, it indicates that these varieties show better adoption to the favourable environment. The deviation from regression (S^2d_i) value for all the genotypes were negative. It indicates that the varieties are also fit for poor environments. For number of pods per plant, 'DWD-FB-1' had highly significant b_i value and equal or near to unity. This revealed that the variety is stable over the environments for this trait. Whereas, the varieties 'HAFB-3', 'HAFB-4', 'VLFB-130' and 'IIHR-909' exhibits lower than unity b_i value and negative S^2d_i value. It means that these are stable for the unfavorable environment.

For pod yield per plant, the variety 'DWD-FB-1' (199.12 g) and 'Arka Anoop' (198.48 g) recorded highest mean over the environment (Table 3). The variety 'DWD-FB-1' recorded highly significant negative b_i value. It indicates that the variety is suitable for the poor environments, where as 'IIHR-909' (0.94) has near to one b_i value and it indicates better adoption over the environments. High S^2d_i values were noticed in all the varieties for this trait. This shows that they are very highly sensitive to environments. Under favourable condition these varieties can yield maximum. With regard to green pod yield per hectare, the variety' DWD-FB-1' recorded highest yield of 8.36 t/ha, 8.12 t/ha and 8.63 t/ha in 2005, 2006 and 2007 respectively. Environmental index of 2006 was more favourable (I=0.095) with highest

Table 3. Estimates of stability parameters for growth and yield characters in French bean.

Genotypes	Days to 50% flowering			Plant height (cm)			Pod length (cm)			Pod girth (cm)		
	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
HAFB-3	33.11	1.30*	2.81	47.39	2.27	2.78	13.77	1.16	-0.23	0.73	0.80**	0.02
HAFB-4	32.78	0.62	-0.85	43.04	-0.93	-0.45	13.52	1.38	0.55	0.77	1.06**	0.02
DWD-FB-1	33.33	1.74	-0.85	51.31	0.10	2.04	16.23	0.04**	3.54	0.65	0.42**	0.02
Arka Anoop	34.11	1.20	0.94	47.00	1.80	-1.63	15.84	1.56	-0.17	0.86	1.62	0.00
VLFB-2004	34.33	0.96	-0.03	41.81	-3.02**	21.90	15.12	1.50	0.04	0.72	1.04	0.00
VLFB-130	34.67	1.32	-0.83	48.11	3.86	-1.91	14.97	0.83**	3.32	0.80	1.16	0.01
IIHR-909	33.89	0.30*	3.70	43.67	1.39**	56.67	13.56	0.81**	3.18	0.81	1.07	-0.00
Contender	35.00	0.55	-0.12	46.87	1..63	-1.10	14.80	0.75**	11.31	0.82	0.84	0.01
Population Mean	33.90	1.00		46.15	1.00		14.73	1.00		0.77	1.00	
Std. Err. Mean	0.86	0.36		2.42	2.78		1.22	1.03		0.07	0.35	

Table 3: *Contd...*

	Average pod weight (g)			No. of pods per plant			Green pod yield per plant (g)		
	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
HAFB-3	7.32	-1.42	-0.15	37.34	0.92	-3.94	170.64	2.07	-16.64
HAFB-4	7.8	0.63	-0.15	40.00	0.21	-5.35	147.71	1.19	-98.04
DWD-FB-1	10.22	3.94	-0.15	37.40	1.04**	44.90	199.12	-0.01**	583.19
Arka Anoop	8.55	1.12	-0.16	33.86	1.28	-5.17	198.48	0.10	-105.71
VLFB-2004	6.97	0.08	-0.15	32.94	1.49	-1.72	164.61	1.75**	1847.88
VLFB-130	7.12	-1.85	-0.16	32.78	0.57	7.25	139.80	1.54*	438.36
IIHR-909	6.62	3.66	-0.14	31.17	0.50	12.82	142.28	0.94*	518.63
Contender	7.00	1.84	-0.16	32.89	1.99	5.94	168.87	0.42**	4129.03
Population Mean	7.61	1.00		34.80	1.00		166.44	1.00	
Std. Err. Mean	0.07	0.38		2.48	0.84		22.44	1.25	

* Significant at 5% level and ** significant at 1% level

Table 4. French bean varieties green pod yield (t/ha) for 2005, 2006 and 2007 and their stability estimates.

Genotypes	Green pod yield (t/ha)				b_i	S^2d_i
	2005	2006	2007	Mean		
HAFB-3	8.10	8.12	6.58	7.60	-1.52**	1.35
HAFB-4	4.62	6.42	6.30	5.78	8.82	-0.04
DWD-FB-1	8.36	8.12	8.63	8.37	-0.67	-0.05
Arka Anoop	7.57	5.65	7.28	6.84	-7.78*	0.49
VLFB-2004	5.15	5.39	5.59	5.38	1.38	-0.12
VLFB-130	4.84	6.28	5.74	5.62	6.54	-0.17
IIHR-909	6.19	4.94	5.06	5.40	-6.05	-0.12
Contender	4.32	5.96	5.16	5.15	7.27	-0.12
Population Mean	6.23	6.38	6.29	6.27	1.00	
Std. Err. Mean	0.45	0.32	0.23	0.40	3.63	
Env. Index (I)	-0.121	0.095	0.026			

*Significant at 5% level and ** significant at 1% level

population mean yield of 6.38 t/ha (Table 4). 'DWD- FB-1' (8.37 t/ha) and 'HAFB-3' (7.60 t/ha) recorded highest mean yield over the environments. The genotype 'DWD-FB-1' recorded negative b_i value (-0.62) but near to unity as it falls between 1 and -1 regression coefficient (Fig. 1) and S^2d_i ($-0.05 \simeq 0$) value is also negative but almost equal to zero. It indicates that the variety 'DWD-FB-1' is stable and also performs well even under unfavourable environments.

Considering the overall performance, the magnitude of regression coefficient and deviation from regression varied from genotype to genotype. It is confirmed with the work of Dethe and Dumbre (2). Selection of genotypes for stability is needed in most of the tropical and sub-tropical environments where the environment is variable

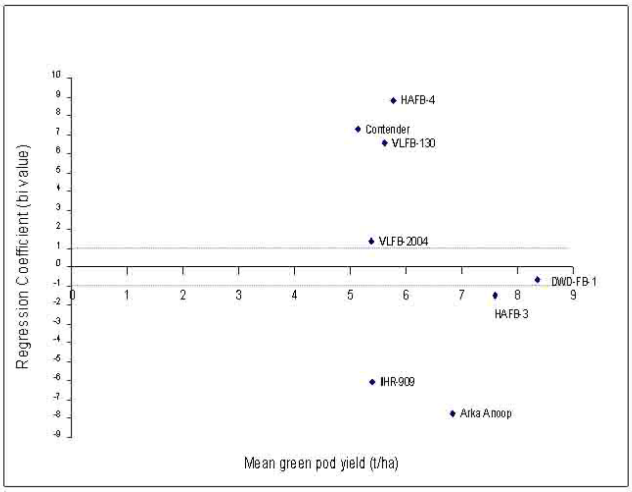

Fig. 1. Distribution of snap bean genotypes by their mean yield.

and unpredictable. Both yield and stability of performance should be considered simultaneously to exploit the useful effect of genotype x environment interaction and to make selection of the genotypes more precise and refined. Therefore, genotype evaluation under variable environments and adoption of simultaneous selection for yield and stability is the most valuable selection index that can be used in any vegetable improvement programme. Among eight genotypes, 'DWD-FB-1' and 'HAFB-3' showed superiority for maximum number of traits and had high mean for yield per hectare. These varieties can be grown successfully in *kharif* under the northern transitional tract of Karnataka as the farmers would prefer to use a high yielding cultivar that performs consistently from year to year.

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