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Stability of green pod yield and its components in faba bean (*Vicia faba* L.)

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ABSTRACT

An experiment was conducted during winter season (October-February) (2008, 2009 & 2010) to study the stability parameters, *viz*., regression coefficient (bi) and mean square deviations (s^2di) from linear regression, along with *per-se* performance of 20 faba bean genotypes for 10 green pod yield related traits. The genotype HAVFB-41 (23.74 t/ha) was the top green pod yielder, stable and suitable for favourable environment, while it was also suitable for unfavourable environment for days to 1st picking (88.33 days), pod breadth (1.12 cm) and pod girth (1.04 cm). The genotype HAVFB-37 was also promising, stable and suitable for favourable environment for green pod yield (23.06 t/ha), number of branches/ plant (6.18), harvest index (51.41%) and pod length (6.13 cm).

Key words: Faba bean, green pod yield, performance, stability.

INTRODUCTION

Faba bean (*Vicia faba* L.), also known as broad bean, horse bean, Windsor bean, English bean, tick bean, field bean, winter bean and pigeon bean, is one of the oldest cultivated crops. It is popularly known as poor man's vegetable and is a member of the family Fabaceae. It plays an important role in world agriculture owing to its high protein content, ability to fix atmospheric nitrogen and capacity to grow and yield well even on marginal land and at high altitudes. The crop is mainly used as a pulse in states like Bihar, Uttar Pradesh, Himachal Pradesh and North Eastern states of India. The crop is grown in cool season in a limited scale in home gardens in regions of higher altitude of India for use as cooked green pod vegetable. There is no report of recommended stable cultivar of faba bean for these regions, which is high yielding and suitable for green pod harvest. In this context, faba bean germplasm of were collected through survey in the state of Bihar and evaluated at ICAR Research Complex for Eastern Region Research Centre, Ranchi, Jharkhand, which is located in Eastern Plateau and Hill regions. This resulted in isolation of 20 promising genotypes. Hence, the need of the hour is to identify and recommend a few high yielding and stable genotypes of vegetable type Faba bean for the Eastern Plateau and Hill Region of India.

The success of a new vegetable type faba bean variety depends on its yield and adaptation potential in those locations. Evaluation of stability performance and range of adaptation has become increasingly important in breeding programs (Akçura *et al*., 1). Genotype × Environment interactions (GEI) are of major importance, because they provide information about the effects of different environments on cultivar performance and play a key role for assessment of performance stability of the breeding materials (Moldovan *et al*., 6). Stable genotypes have the same reactions with high yield or performance (Björnsson, 2). Thus, maximizing yield in particular areas are explained by GEI (Peterson *et al*., 7). This interaction is the differential response of genotypes evaluated under different environmental conditions. It is a complex phenomenon as it involves environmental (agro-ecological, climate and agronomic) conditions and all physiological and genetic factors that determine the plant growth and development (Kaya *et al*., 4). Eberhart and Russel (3) proposed a model to test the stability of different environments. They indicated a stable variety as having unit regression over the environments (bi = 1.0) and minimum deviation from the regression ($S^2di = 0$). Therefore, a variety with a high mean yield over the environments, unit regression coefficient (bi = 1.0) and deviation from regression as small as possible ($S^2di = 0$), will be a better choice as a stable variety.

The stability parameters have been studied by Karadavut *et al.* (5) for grain yield parameters in 6 selected faba bean genotypes. However, there is no information on stability of green pod yield and its components in faba bean. With this background, the promising genotypes of faba bean were evaluated to identify a few stable and high green pod yielding genotypes to be suitable for commercial cultivation through stability analysis.

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MATERIALS AND METHODS

Twenty vegetable type faba bean genotypes, *viz*., HAVFB-2, HAVFB-4, HAVFB-6, HAVFB-7, HAVFB-12, HAVFB-14, HAVFB-15, HAVFB-16, HAVFB-20, HAVFB-27, HAVFB-28, HAVFB-31, HAVFB-33, HAVFB-37, HAVFB-39, HAVFB-41, HAVFB-43, HAVFB-52 and HAVFB-62 collected through survey from different parts of Bihar state of India and a released variety Pusa Sumeet collected from ICAR-Indian Agricultural Research Institute, New Delhi were grown during winter season (October-February) for three seasons (2008, 2009 and 2010). An experiment on each environment (year) was conducted in randomized block design with three replications. A spacing of 60 cm x 15 cm was maintained. Observations on a set of ten agro-morphological traits, *viz.*, green pod yield /plant, days to 50% flowering, days to 1st picking, plant height, number of branches/ plant, harvest index, pod weight, pod length, pod breadth and pod girth were based on 10 randomly selected plants in each replication. The data were analyzed statistically for stability parameters based on Eberhart and Russel (3) model.

RESULTS AND DISCUSSION

The analysis of variance of pooled data indicated highly significant differences among the genotypes for all the characters studied except pod breadth and number of branches/ plant, whereas significant differences were observed among the environments. Karadavut *et al.* (5) through pooled analysis of variance also observed highly significant differences among six faba bean genotypes and environments in respect of grain yield. However, stability analysis of variance of mean data indicated significant differences among the genotypes for green pod yield/ plant, days to 1st picking, plant height, pod weight, pod length and pod girth (Table 1). The environment + G × E interactions were highly significant when tested against pooled error for all the characters except pod breadth which satisfied the requirement of stability analysis, *i.e.* the genotypes interacted considerably with environment in expression of the character. Highly significant mean sum of squares due to environment (linear) for all the characters indicated considerable differences among the environments and their predominant effects on the characters. This was due to variation in weather conditions during different years and locations. Highly significant and higher magnitude of linear component of G x E interactions and non-significant and lower magnitude of pooled deviation for green pod yield/ plant and days to 1st picking indicated

Table 1. Stability analysis of variance of mean data for ten traits in faba bean.

Source	DF	Mean sum of squares								
		Green pod yield/ plant	Days to 50% flowering	Days to 1st picking	Plant height	No. of branches/ plant	Harvest index	Pod weight	Pod length	Pod width	Pod girth
Var.	19	616.89**	3.64	2.39*	70.73*	0.61	22.04	0.14**	0.15**	0.0012	0.0014*
Env. + (Var. × Env.)	40	2254.86**	8.68**	52.21**	453.57**	1.42**	41.75**	0.07**	0.14**	0.0001	0.0001**
Env. (L)	1	74313.26**	289.21*	1997.56**	16980.66**	32.76**	1016.30**	1.73**	3.96**	0.0173**	0.0263**
Var. × Env. (L)	19	656.91**	1.18	3.61**	29.4	0.43	20.36	0.01	0.04	0.0015	0.0011
Pooled deviation	20	169.95	1.78**	1.11	30.18	0.79	13.35	0.04	0.04	0.0009	0.0007
Pooled error	120	153.69	0.49	0.94	31.11	0.52	9.17	0.04	0.03	0.0011	0.0007

*, ** Significant at 0.05 & 0.01 probability levels, respectively

linear response of the genotypes due to change in environment. Significant pooled deviation for days to 50% flowering indicated non-linear response of the genotypes due to environmental changes and role of unpredictable components of G × E interaction towards differences in stability of the genotypes. However, even for unpredictable traits, prediction can still be made on considering stability parameters of individual genotypes (Singh *et al*., 8).

Eberhart and Russel (3) suggested an ideal genotype as one having high mean performance, regression coefficient (bi) near unity and deviation from regression (s^2di) near zero. The genotypes HAVFB-41 (213.93 g/plant; 23.74 t/ha) and HAVFB-37 (207.76 g/ plant; 23.06 t/ha) were among the top performers and recorded green pod yield more than population mean (188.51 g/plant; 20.92 t/ha) and the released variety Pusa Sumeet (188.63 g/plant; 20.93 t/ha) (Table 2). Both the lines recorded bi values >1 and negative and non-significant s^2di values, which indicated their stability and adaptation to specific favourable environments. These two stable and high yielding genotypes can be recommended for better management conditions. Genotype HAVFB-7 was the earliest to flower in 35.77 days after sowing (population mean 37.46 days after sowing) and with bi value >1 and non-significant and very low s^2di value indicated its stability and adaptation to specific favourable environment.

Eleven genotypes including the high yielding line HAVFB-41 took 88.33 days for 1st picking and were earlier than population mean (89.04 days after sowing). HAVFB-41 with bi value <1 and negative and non-significant s^2di value indicated its stability and adaptation to unfavourable environments. The highest yielder HAVFB-43 (96.74 cm) recorded plant height more than population mean (89.92 cm), bi value <1 and negative s^2di value, which indicated its stability and adaptation to unfavourable environments. Genotype HAVFB-37 (6.18) recorded number of branches/ plant more than population mean (5.54), bi value >1 and negative s^2di value, which indicated its stability and adaptation to specific favourable environment. Genotypes HAVFB-4 (51.72%) and HAVFB-37 (51.41%) were the top performers regarding harvest index (population mean 47.88%). Both the genotypes recorded bi values >1 and negative/very low s^2di values which indicated their stability and adaptation to specific favourable environment.

Genotypes HAVFB-52 (3.56 g), HAVFB-62 (3.42 g), HAVFB-43 (3.32 g), HAVFB-4 (3.24 g) and HAVFB-6 (3.22 g) performed better than population mean (3.04) in respect of pod weight. Similarly, genotypes HAVFB-52 and HAVFB-6 recorded bi values >1 and very low/ zero s^2di value indicating their stability and adaptation to specific favourable environments, whereas HAVFB-43, HAVFB-62 and HAVFB-4 recorded highly significant bi values <1 and zero s^2di values, which indicated their stability and adaptation to unfavourable environments.

Genotypes HAVFB-4 (6.23 cm), HAVFB-52 (6.22 cm), HAVFB-33 (6.19 cm) and HAVFB-37 (6.13 cm) were the top performers regarding pod length (population mean 5.90 cm). HAVFB-4 and HAVFB-33 recorded bi values <1 and zero s^2di values which indicated their stability and adaptation to unfavourable environment, whereas HAVFB-37 and HAVFB-52 recorded bi values >1 and zero s^2di values indicating their stability and adaptation to specific favourable environments. While, HAVFB-52 (1.15 cm) and HAVFB-41 (1.12 cm) were the top performers regarding pod breadth (population mean 1.09 cm). HAVFB-52 recorded value >1 and zero s^2di value, which indicated its stability and adaptation to specific favourable environments whereas HAVFB-41 recorded bi value <1 and zero s^2di value, which indicated its stability and adaptation to unfavourable environments. Genotypes HAVFB-52 (1.05 cm) and HAVFB-41 (1.04 cm) were the top performers regarding pod girth (population mean 1.00 cm). HAVFB-52 recorded value >1 and zero s^2di value, which indicated its stability and adaptation to specific favourable environments, whereas, HAVFB-41 recorded bi value <1 and zero s^2di value, which indicated its stability and adaptation to unfavourable environments.

On the basis of mean performance and stability parameters in respect of green pod yield and its component characters, the suitability of genotypes for different environments has been summarized in Table 3. It can be concluded that among 20 faba bean genotypes, HAVFB-41 and HAVFB-37 could be considered stable and better green pod yielding types and recommended for cultivation in Eastern plateau and Hill Regions of India.

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Table 2. Stability parameters for green pod yield and its contributing characters in faba bean.

Genotype	Branches/plant			Harvest index (%)			Pod weight (g)			Pod length (cm)			Pod breadth (cm)			Pod girth (cm)		
	X	bi	S^2di	X	bi	S^2di	X	bi	S^2di	X	bi	S^2di	X	bi	S^2di	X	bi	S^2di
HAVFB-2	6.03	0.56	0.2	48.37	1.04	-3.1	2.86	1.07	-0.0	5.47	0.86	-0.0	1.11	0.17	-0.0	1.03	-0.34**	-0.0
HAVFB-4	5.55	0.29*	0.6	51.72	2.45**	-4.8	3.24	0.47**	-0.0	6.23	0.12	-0.0	1.10	0.30*	-0.0	1.00	1.14	-0.0
HAVFB-6	5.51	1.04	-0.1	46.61	1.61	11.5	3.24	1.60	-0.0	6.05	0.82	-0.0	1.11	1.27	-0.0	1.02	1.71	-0.0
HAVFB-7	5.66	1.50	-0.5	47.00	0.66	4.3	2.90	1.14	-0.0	5.93	0.73	0.0	1.08	2.25	-0.0	0.98	1.85	-0.0
HAVFB-12	5.11	1.18	1.0	50.82	1.41	20.4	2.88	0.84**	-0.0	5.62	1.41	-0.0	1.07	-0.01*	0.0	0.98	0.70**	0.0
HAVFB-14	5.51	1.40	-0.4	49.53	0.94	-4.7	2.84	0.93	-0.0	6.07	0.89	0.0	1.11	1.88	0.0	1.00	2.38	-0.0
HAVFB-15	5.66	0.84	1.5*	49.55	1.64	16.3	2.97	1.03	-0.0	5.99	0.73	-0.0	1.09	2.44	-0.0	0.98	1.93	-0.0
HAVFB-16	5.40	1.96	-0.5	46.66	0.47	-8.2	2.95	0.94	-0.0	5.95	1.65	-0.0	1.07	0.93*	0.0	0.98	1.09	-0.0
HAVFB-20	5.92	1.13	-0.5	42.40	0.20**	30.9	2.90	0.65**	0.0	5.81	0.92	-0.0	1.08	1.63**	-0.0	0.97	1.24	0.0
HAVFB-27	6.40	0.56	1.4	44.55	0.73	0.4	2.76	1.20	-0.0	5.56	0.21	-0.0	1.10	0.68*	-0.0	1.00	0.15*	0.0
HAVFB-28	5.85	1.18	-0.4	48.36	0.73	-4.5	2.84	1.02	-0.0	5.75	0.89	0.0	1.08	0.48*	-0.0	0.97	2.09	-0.0
HAVFB-31	5.33	1.27	-0.5	43.42	0.94	-8.9	2.82	1.47	-0.0	5.75	0.56	-0.0	1.07	3.55*	-0.0	1.01	0.65**	0.0*
HAVFB-33	5.44	0.71	0.4	50.78	1.07	7.0	2.96	0.75**	-0.0	6.19	0.75	-0.0	1.07	0.98*	-0.0	0.99	0.84**	-0.0
HAVFB-37	6.18	1.36	-0.1	51.41	1.66	0.1	3.22	0.50**	0.2	6.13	1.17	-0.0	1.10	-0.66*	0.0*	1.01	-0.50**	-0.0
HAVFB-39	4.59	1.43	-0.4	47.12	1.61	14.1	3.07	0.98	-0.0	5.86	1.70	0.0	1.09	0.69*	0.0	1.01	0.48**	-0.0
HAVFB-41	5.25	1.63	-0.3	48.92	-0.20*	4.4	3.06	1.14	0.0	5.54	1.62	-0.0	1.12	-0.06*	-0.0	1.04	-0.27**	-0.0
HAVFB-43	5.99	0.24*	0.2	44.03	0.13**	3.2	3.32	0.69**	0.0	6.05	1.28	0.0	1.09	-1.49*	-0.0	1.01	-0.27**	-0.0
HAVFB-52	5.07	0.67	-0.5	48.47	0.52	-7.2	3.56	1.99	0.1	6.22	1.52	-0.0	1.15	3.74**	0.0	1.05	2.22	-0.0
HAVFB-62	4.81	1.00	0.4	47.30	1.00	-8.7	3.42	0.63**	0.0	5.95	0.58	0.0	1.10	1.21	-0.0	1.01	1.74	0.0
Pusa Sumeet	5.55	-0.05*	3.7**	50.58	1.31	20.9	3.06	0.86**	-0.0	5.92	1.51	0.2	1.09	-0.04*	-0.0	1.01	1.12	-0.0
General mean	5.54			47.88			3.04			5.90			1.09					
SE (Mean)	0.63			2.58			0.14			0.14			0.02					
SE of bi		0.69			0.51			0.71			0.46			1.03			0.01	

*, ** Significant at 0.05 & 0.01 probability levels, respectively

Table 3. Suitability of stable genotypes of faba bean for important traits.

Genotype	Trait	Response to environment
HAVFB-41	Green pod yield	Responsive in favourable environment
	Days to 1st picking, pod breadth and pod girth	Responsive in unfavourable environment
HAVFB-37	Green pod yield, number of branches/plant, harvest index and pod length	Responsive in favourable environment
HAVFB-7	Days to flowering	Responsive in favourable environment
	Days to 1st picking	Responsive in unfavourable environment
HAVFB-43	Plant height and pod weight	Responsive in unfavourable environment
HAVFB-4	Harvest index	Responsive in favourable environment
	Pod weight and pod length	Responsive in unfavourable environment
HAVFB-52	Pod weight, pod length, pod breadth and pod girth	Responsive in favourable environment

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