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Performance of Broad Bean (*Vicia faba* L.) Genotypes for Pod Yield and Yield Contributing Morpho-physiological Components under Mid Hill Conditions of North Western Himalayas

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Authors' contributions

This work was carried out in collaboration between all authors. Author YS designed the study, wrote the protocol and the first draft of the manuscript. Author Simran Sharma conducted the research and collected the data. Authors BSS and Surbhi Sharma analyzed the data and helped in framing the final manuscript. Author AV managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The present investigation was planned to evaluate thirty five broad bean genotypes along with one check Vikrant-B for yield and some yield contributing morpho-physiological components.
Study Design: Randomized Block Design.
Place and Duration of Study: The experiment was undertaken at Experimental farm of the Department of Vegetable and Floriculture CSK HPKV, Palampur situated at 32°6' N latitude and 76° 3' E longitude at an elevation of 1290.8 m amsl during 2015-16.
Methodology: The experimental material constituted thirty five genotypes along with one check collected from different parts of country. Observations were recorded on ten randomly selected plants in each replication on days to 50% flowering, node at which 1st flower appears, branches per

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plant, nodes per plant, plant height (cm), days to maturity, pod length (cm), pods per plant, pod yield per plant (g), pods per node, seeds per pod, seed yield per plant (g), seed size (cm), 100-seed weight, harvest index (%), total soluble solids (^{o}Brix), dry matter (%), ascorbic acid (mg/100 g) and protein content (%). The analysis was carried out using OPSTAT Software following the method suggested by Singh and Chaudhary (1977).

Results: The analysis of variance revealed that mean squares due to genotypes were significant for all the traits. On the basis of mean performance, 'Local-1-C' was the top ranking genotype for pod yield per plant which significantly outperformed all the genotypes with an increase of 30.83 per cent over check 'Vikrant-B'. Further, genotypes viz., HB-123-B and HB-123-C showed superiority for both pod yield and seed yield per plant over check and other genotypes.

Conclusion: The best performing genotypes could be used for further evaluation under different environments to be released as a variety (s) or under hybridization programmes for Broad bean improvement.

Keywords: Broad bean; evaluation; genotypes; pod yield per plant; seed yield per plant.

1. INTRODUCTION

Faba bean (*Vicia faba* L.; Family: Fabaceae), also referred as broad bean, horse bean, bakla bean, winter bean, field bean, bell bean, English bean, Windsor bean, pigeon bean, tic(k) bean, common bean and locally known as kyoon. It is one of the important legume crop of the world cultivated both under irrigated and rainfed conditions [1]. It is of great importance in world agriculture due to its high yield potential compared to alternative grain legumes and it can be used as break crop where cereal based mono-cropping system is dominated and it replenishes soil nutrients through biological nitrogen fixation (up to 300 kg/ha) and reduced biological pests [2]. It also helps to mitigate global concerns like diminishing nutritional security, climate change and sustainability in agriculture. This crop needs to be encouraged to fit into the changing food habits, life styles and above all climate change. There were few research reports on the performance of broad bean genotypes wherein these were evaluated by Singh et al. [1], Ammar et al. [3], Ahmed et al. [4] and Gasim et al. [5]. In their respective genetic material under different environments. But, in india, systemic efforts have not been undertaken to seek improvement of this crop. Therefore, there is an urgent need to undertake suitable breeding programme to seek genetic upgradation of this crop.

In Himachal Pradesh, faba bean is grown sparingly but fetches high prices, despite being an underexploited crop. Since it is not grown commercially in the state and hence no standard variety has been developed for the growers of this region. Probably, the non-availability of high yielding varieties with quality pods constitutes the major limiting factor of this crop. Keeping these factors in view a systematic collection of local strains as well as outside the state was initiated in the Department of Vegetable Science, CSK HPKV, Palampur for developing improved variety(s) of this vegetable crop. The present investigation was taken up to evaluate thirty five broad bean genotypes from such collection along with one check for pod yield and some yield contributing morpho-physiological components.

2. MATERIALS AND METHODS

The experimental material constituted thirty five genotypes along with one check was collected from different parts of country (Table 1). The experiment was undertaken at Experimental farm of the Department of Vegetable and Floriculture CSK HPKV, Palampur situated at 32° 6' N latitude and 76° 3' E longitude at an elevation of 1290.8 m above mean sea level. The location is characterized by humid and temperate climate with an annual rainfall of 2,500 mm of which 80% is received during June to September and represents the mid-hill zone of Himachal Pradesh. Seeds were directly sown in the month of October, 2015 at a spacing of 25×10 cm within row to row and plant to plant, respectively. The experiment was laid out in randomized complete block design (RBD) with three replications. The standard cultural practices to raise the healthy crop were followed as per the recommendations of package of practices for vegetable crops. The data for different characters was analyzed for variability (ANOVA) as per Gomez and Gomez [6]. The calculated 'F' value was compared with the tabulated 'F' value at 5 per cent level of significance. If the calculated 'F' value was higher than the tabulated, it was considered to be significant.

Table 1. List of genotypes and their source

S. no.	Genotypes	Source
1	Local -2-A	CSKHPKV Palampur
2	HB-193-A	CSKHPKV Palampur
3	HB-40-A	CSKHPKV Palampur
4	HB-511-C	CSKHPKV Palampur
5	HB-123-C	CSKHPKV Palampur
6	HB-131-A	CSKHPKV Palampur
7	HB-43-A	CSKHPKV Palampur
8	HB-43-B	CSKHPKV Palampur
9	HB-123-A	CSKHPKV Palampur
10	Local-1-C	CSKHPKV Palampur
11	DPFB-2A	CSKHPKV Palampur
12	Local-1-B	CSKHPKV Palampur
13	HB-131-B	CSKHPKV Palampur
14	Local-1-A	CSKHPKV Palampur
15	HB-65-B	CSKHPKV Palampur
16	PRT-7-B	CSKHPKV Palampur
17	HB-504-B	CSKHPKV Palampur
18	HB-193-C	CSKHPKV Palampur
19	HB-115-D	CSKHPKV Palampur
20	HB-504-A	CSKHPKV Palampur
21	HB-115-B(Brown)	CSKHPKV Palampur
22	HB-193-B	CSKHPKV Palampur
23	HB-504-C	CSKHPKV Palampur
24	HB-115-A	CSKHPKV Palampur
25	HB-115-E	CSKHPKV Palampur
26	HB-613-A	CSKHPKV Palampur
27	Local-2-B	CSKHPKV Palampur
28	HB-649-B	CSKHPKV Palampur
29	HB-649-C	CSKHPKV Palampur
30	ISV-10-2-C	CSKHPKV Palampur
31	HB-65-A	CSKHPKV Palampur
32	HB-511-B	CSKHPKV Palampur
33	HB-115-B(Green)	CSKHPKV Palampur
34	HB-123-B	CSKHPKV Palampur
35	Vikrant-B (Check)	CCS HAU Hisar

Observations were recorded on ten randomly selected competitive plants in each replication on days to 50% flowering, node at which 1st flower appears, branches per plant, nodes per plant, plant height (cm), days to maturity, pod length (cm), pods per plant, pod yield per plant (g), pods per node, seeds per pod, seed yield per plant (g), seed size (cm), 100-seed weight, harvest index (%), total soluble solids (^{o}Brix), dry matter (%), ascorbic acid (mg/100g) and protein content (%) which was estimated by following the method suggested by A.O.A.C. [7]. The analysis was carried out using OPSTAT Software.

3. RESULTS AND DISCUSSION

The analysis of variance revealed that mean squares due to genotypes were significant for all the morphological, yield and yield contributing traits highlighting the presence of sufficient genetic variability among the genotypes (Table 2).

Ammar et al. [3], Abid et al. [8] and Ahmed et al. [4] also reported variability in their respective genetic material of faba bean. The presence of sufficient genetic variation for different traits indicates the scope for selecting better genotypes with desirable attributes.

3.1 Growth and Yield Parameters

3.1.1 Earliness

Earliness is a highly desirable trait in all vegetables as the market prices are invariably high in the early season. In this context, it was observed that best performing genotypes for yield ranged from early to late on the basis of days to 50 per cent flowering and maturity. There was substantial variation for this trait among all the genotypes with a range of 57.73 to 72.00 days. Two genotypes *viz*., Local-1-B (57.73days) and ISV-10-2-C (59.20 days) were found to be earliest as these took significantly lesser number of days to flowering among all the genotypes including check Vikrant-B. While the genotypes viz., Local-2-A (59.70), HB-123-C (60.27) and HB-40-A (60.50) were statistically at par with check. Twenty nine genotypes viz.,HB-193-A, HB-511-C, HB-131-A, HB-43-B, HB-123-A, Local-1-C, DPFB-2A, HB-131-B, Local-1-A, HB-65-B, PRT-7-B, HB-504-B, HB-193-C, HB-115-D, HB-504-A, HB-115-B(Brown), HB-193-B, HB-504-C, HB-115-A, HB-115-E, HB-613-A, Local-2-B, HB-649-B, HB-649-C, HB-65-A, HB-511-B, HB-115-B(Green), HB-123-B and HB-43-Atook more number of days to 50 per cent flowering than the check. The differences for days to 50 per cent flowering were also reported by Ammar et al. [3], Ahmed et al. [4] and Sheelamary et al. [9].

3.1.2 Pods per node

Three genotypes *viz*., HB-504-C (1.91), HB-504-B (1.83) and HB-43-A (1.73) were the top three among nineteen genotypes that bore significantly highest number of pods per node when compared with check Vikrant-B, while rest of fifteen genotypes were found to be statistically at par with check variety for this trait. A wide variation in the performance for pods per node in different genotypes was also observed by Abid et al. [8].

Table 2. Analysis of variance for randomized block design with respect to pod yield per plant and other traits in faba bean genotypes

Sources of variation		Mean sum of squares due to		
		Replications	Genotypes	Error
Traits	df	2	34	68
Days to 50 per cent flowering		1.31	42.13*	1.18
Node at which first flower appears		1.18	73.56*	1.00
Pods per node		0.01	0.11*	0.01
Nodes per plant		9.72	619.64*	1.55
Pod length (cm)		0.01	0.55*	0.05
Pods per plant		8.87	604.44*	1.55
Plant height (cm)		3.15	234.06*	1.49
Branches per plant		0.01	1.58*	0.02
Seeds per pod		0.01	0.75*	0.05
Days to maturity		0.12	482.23*	1.87
Seed yield per plant (g)		2.43	59.53*	1.42
Seed size (cm)		0.01	0.08*	0.01
100- seed weight (g)		0.05	105.07*	0.85
Harvest index (per cent)		0.84	47.94*	0.90
Total soluble solids (^{o} Brix)		0.09	0.81*	0.01
Ascorbic acid (mg/100g)		0.06	10.34*	0.07
Dry matter (per cent)		0.03	12.75*	0.01
Protein content (per cent)		0.07	32.90*	0.11
Pod yield per plant (g)		7.65	314.77*	2.42

**Significant at P ≤0.05*

3.1.3 Nodes per plant

It is important to have more number of nodes per plant as these have direct impact on total yield. Highest number of nodes per plant were recorded in Local-1-C (172.75) followed by HB-504-B (171.37), HB-115-D (165.23), PRT-7-B (161.80) also in fourteen other genotypes, while twelve genotypes were found to be at par and four genotypes namely, HB-40-A, HB-115-E, HB-613-A, Local-2-B have lesser number of nodes per plant as compared with the check 'Vikrant-B' for this trait. as compared with the check 'Vikrant-B' for this trait. Wide variation for nodes per plant in different genotypes has also been noticed by Mulualem et al. [10].

3.1.4 Pod length

More the pod length, more will be the number of seeds per pod and hence higher yields. The genotypes under study exhibited significant differences for this trait. Local-2-B (7.45cm) followed by HB-613-A (7.13cm) and ISV-10-2-C (7.01cm) along with twenty two other genotypes were found to have longest pod length than the check Vikrant-B. While eight genotypes *viz*., HB-511-B, HB-193-A, HB-123-C, HB-511-C, HB-123-A, HB-115-B (Brown), HB-649-C and HB-40-A were found to be at par when compared with check for this trait. Sheelamary et al. [9] and Shrifi [11] also noticed a wide range of variability for pod length in their respective genetic material evaluated under different sets of environments.

3.1.5 Pods per plant

High yield is the basic objective of all crop improvement programmes. It is of immense importance to develop a genotype which has a potential to surpass a commercially adopted/adapted cultivar(s) otherwise the genotype will be of less significance even if it has excellent performance for other traits. Number of pods per plant has a direct effect on the total productivity of faba bean crop. The trait showed significant variation among genotypes. The genotype HB-123-B (71.87) followed by Local-1-C , HB-123-C and eight other genotypes *viz*., Local-2-A, HB-193-A, HB-40-A, HB-511-C, HB-131-A, HB-131-B, DPFB-2A, PRT-7-B have comparable pods per plant with check Vikrant-B, while remaining twenty three genotypes were found to have less number of pods per plant as compared to check. Variation for pods per plant has also been observed by Ammar et al. [3].

Table 3. Mean performance of 35 faba bean genotypes for yield, yield attributing traits

	Trait / Genotypes	Days to 50 per cent flowering	Node at which first flower appears	Pods per node	Nodes per plant	Pod length (cm)	Pods per plant	Plant height (cm)	Branches per plant	Seeds per pod	Days to maturity	Seed yield per plant (g)	Seed size (cm)	100- seed weight (g)	Pod yield per plant (g)
1.	Local-2-A	59.70	3.17	1.72	153.36	5.90	60.67	97.75	8.54	4.04	193.20	36.44	1.60	39.20	43.18
2.	HB-193-A	65.13	2.85	1.55	159.86	5.70	61.67	104.82	8.73	4.06	213.13	39.02	1.66	46.21	45.33
3	HB-40-A	60.50	2.78	1.41	123.86	5.21	63.53	92.11	9.26	4.11	212.47	40.24	1.65	44.40	46.67
4.	HB-511-C	65.20	3.78	1.06	161.39	5.57	64.30	109.06	9.11	4.13	187.80	32.12	1.63	45.82	48.00
5.	HB-123-C	60.27	3.06	1.34	133.02	5.59	70.80	106.50	9.01	3.52	213.00	41.96	1.70	51.59	51.00
6.	HB-131-A	66.00	3.34	1.33	161.12	6.42	60.60	113.50	7.80	3.46	215.87	33.41	1.66	46.99	42.67
7.	HB-43-A	67.53	2.33	1.73	160.90	6.42	35.00	114.00	6.90	3.20	212.93	27.87	1.67	46.92	25.33
8.	HB-43-B	66.27	2.56	1.39	155.10	5.97	54.33	94.05	9.81	3.56	211.27	30.04	1.54	30.56	36.56
9.	HB-123-B	65.93	3.79	1.08	156.24	6.73	71.87	107.41	9.67	4.35	188.80	41.81	1.75	55.33	54.00
10.	Local-1-C	70.53	2.28	1.44	172.75	6.03	71.00	115.25	8.42	4.47	214.67	31.15	1.59	34.13	66.67
11.	DPFB-2A	66.07	2.28	1.36	152.32	6.51	63.53	91.95	8.28	3.09	200.47	30.09	1.61	39.31	42.22
12.	Local-1-B	57.73	3.44	1.28	150.92	6.08	51.00	97.25	8.10	4.07	198.33	29.55	1.69	47.37	36.33
13.	HB-131-B	61.20	3.16	1.42	158.30	6.46	60.27	101.08	9.40	4.36	214.93	24.23	1.52	28.61	44.56
14.	Local-1-A	64.87	1.50	1.58	141.54	6.27	42.80	97.58	8.59	3.29	213.60	30.46	1.63	40.52	30.33
15.	HB-65-B	63.20	3.56	1.39	150.30	6.15	50.80	98.83	8.13	4.35	181.90	30.17	1.73	53.65	36.22
16.	PRT-7-B	62.27	4.00	1.70	161.80	6.56	59.40	115.16	8.50	4.34	212.20	34.84	1.63	45.21	46.87
17.	HB-504-B	65.40	4.56	1.83	171.37	6.35	52.60	113.00	8.20	3.35	183.40	27.89	1.65	44.93	36.45
18.	HB-193-C	71.40	3.42	1.61	151.89	6.69	51.80	114.75	7.57	4.41	210.73	27.99	1.60	37.92	38.67
19.	HB-115-D	62.00	4.11	1.64	165.23	6.26	43.87	113.83	7.98	4.13	212.40	30.63	1.62	40.67	35.33
20.	HB-504-A	69.73	2.53	1.70	130.79	6.02	36.19	92.82	6.89	4.07	170.24	26.51	1.58	34.29	30.57
21.	HB-115-B(Brown)	70.74	2.50	1.50	144.15	5.38	42.20	113.75	9.12	4.12	194.70	31.10	1.64	44.21	38.89
22.	HB-193-B	61.40	3.33	1.56	161.64	6.38	33.13	115.67	9.52	4.18	216.53	24.37	1.62	42.19	25.22
23.	HB-504-C	65.00	4.08	1.91	135.96	6.72	35.27	98.50	8.06	4.36	210.40	22.88	1.54	30.31	26.22
24.	HB-115-A	65.33	3.44	1.61	136.28	6.10	38.13	93.83	6.80	3.46	188.20	31.89	1.68	45.08	31.11
25.	HB-115-E	70.53	3.72	1.39	122.43	6.51	27.00	98.75	8.37	4.53	212.67	29.92	1.69	42.16	23.11
26.	HB-613-A	67.47	3.72	1.45	120.81	7.13	24.60	104.08	7.43	4.84	181.13	31.74	1.71	53.81	24.52

	Trait / Genotypes	Days to 50 per cent flowering	Node at which first flower appears	Pods per node	Nodes per plant	Pod length (cm)	Pods per plant	Plant height (cm)	Branches per plant	Seeds per pod	Days to maturity	Seed yield per plant (g)	Seed size (cm)	100- seed weight (g)	Pod yield per plant (g)
27.	Local-2-B	66.00	2.50	1.67	121.96	7.45	34.80	104.33	8.57	5.00	213.27	30.73	1.71	51.63	28.22
28.	HB-649-B	66.25	3.33	1.44	143.12	6.28	47.90	106.58	9.06	4.30	212.20	29.29	1.69	47.92	35.00
29.	HB-649-C	70.73	3.28	1.67	153.34	5.36	34.20	113.37	9.07	4.47	213.55	29.15	1.61	40.87	30.00
30.	ISV-10-2-C	59.20	3.83	1.39	146.37	7.01	27.43	101.58	8.42	4.78	182.50	26.67	1.62	42.05	38.00
31.	HB-65-A	72.00	3.30	1.50	171.14	6.70	32.53	123.25	8.98	4.44	210.07	29.84	1.72	52.23	25.78
32.	HB-511-B	68.80	3.22	1.72	143.82	5.86	47.90	110.75	7.33	4.45	197.40	32.27	1.66	46.86	32.44
33.	HB-115-B(Green)	65.87	3.51	1.59	161.69	6.48	23.53	93.50	8.34	4.30	214.27	28.08	1.71	51.87	21.59
34.	HB-123-A	65.07	3.50	1.61	152.08	5.41	44.53	116.33	8.68	4.56	185.33	28.88	1.68	47.54	28.33
35.	Vikrant-B (Check)	61.47	3.81	1.25	140.79	5.50	63.40	91.60	8.38	3.92	182.80	32.05	1.60	38.79	46.11
	Range	57.73-72.00	1.50-4.56	1.06-1.91	120.81-172.75	5.21-7.45	23.53-71.87	91.60-123.25	6.80-9.81	3.20-5.00	170.24-216.53	22.88-41.96	1.52-1.75	28.61-55.33	21.59-66.67
	Mean	65.33	3.24	1.51	149.36	6.20	48.07	105.04	8.43	4.11	202.18	31.00	1.65	43.75	36.90
	SE(m) ±	0.635	0.175	0.079	3.368	0.106	3.085	2.179	0.128	0.080	4.575	3.030	0.008	2.549	3.421
	CV (per cent)	1.691	9.439	9.101	3.932	2.856	10.952	3.636	2.672	3.440	3.948	16.769	0.857	10.966	16.229
	CD (P ≤ 0.05)	1.796	0.495	0.224	9.526	0.301	8.725	6.163	0.363	0.227	12.94	8.571	0.023	7.210	9.676

SE(m) ±; Standard Error of mean; CV; Coefficient of variation ' CD; Critical difference

3.1.6 Plant height

DPFB-2A (91.95 cm), HB-40-A (92.11 cm), HB-504-A (92.82 cm), HB-115-B (Green) (93.50 cm) and HB-115-A (93.83 cm) were the most promising top five genotypes with desired medium plant height. Eleven genotypes *viz*., HB-43-B (94.05), Local-1-B (97.25), Local-1-A (97.58), Local-2-A (97.75) HB-504-C (98.50) and HB-115-E (98.75) were at par with the check, while twenty three genotypes *viz*., HB-193-A, HB-511-C, HB-123-C, HB-131-A, Local-1-C, HB-123-B, HB-65-A, HB-131-B, PRT-7-B, HB-504-B, HB-193-C, HB-115-D, HB-115-B(Brown), HB-193-B, HB-613-A, Local-2-B, HB-649-B, HB-649-C, ISV-10-2-C, HB-65-B, HB-511-B, HB-123-A and HB-43-A were found to have more plant height than check. These results corroborate the findings of Ahmed et al. [4] and Shrifi [11] in their respected genetic material.

3.1.7 Branches per plant

HB-43-B produced significantly maximum number of branches per plant (9.81) followed by HB-123-B (9.67), HB-193-B (9.52) along with eight other genotypes namely, HB-40-A, HB-511-C, HB-123-C, HB-131-B, HB-115-B(Brown), HB-649-B, HB-649-C, HB-65-A including standard check. In addition, sixteen genotypes have comparable branches, while HB-131-A, HB-193-C, HB-115-D, HB-504-A, HB-115-A, HB-613-A, HB-511-B and HB-43-A observed to have less number of branches per plant as compared to check. Ahmed et al. [4] and Shrifi [11] also depicted significant differences for this trait.

3.1.8 Seeds per pod

Local-2-B (5.00) followed by HB-613-A (4.84), ISV-10-2-C (4.78) and fifteen other genotypes were found to have significantly higher number of seeds per pod than check Vikrant-B. While eight other genotypes namely, Local-2-A , HB-193-A , Local-1-B, HB-504-A, HB-40-A, HB-115-B(Brown), HB-511-C, HB-115-D have comparable number of seeds per pod, whereas remaining eight genotypes recorded less number of seeds per pod with respect to check Vikrant-B. The differences for seeds per pod were also reported by Ahmed et al. [4] and Aziz and Osman [12].

3.1.9 Days to maturity

Earliness is a desirable trait as early produce fetches high price in the market. The genotypes used in study showed significant difference for this trait. The earliest maturing genotypes were HB-504-A (170.24) followed by HB-613-A , HB-65-B, ISV-10-2-C, HB-131-A, HB-504-B, HB-123-A, HB-511-C and Local-2-A were also found to be at par with check Vikrant-B, while twenty two genotypes comparatively took more number of days to maturity than check. However maximum number of days for maturity were taken by HB-193-B (216.53) followed by HB-131-A (215.87) and Local-1-C (214.67).The findings are in consonance with Ammar et al. [3] and Ahmed et al. [4].

3.1.10 Seed yield per plant (g)

Seed yield per plant is a very important trait because of the more fold uses of the crop both as vegetable as well as pulse. In this regard, HB-123-C (41.96) and HB-123-B (41.81) were found to be significantly superior to all the genotypes as well as check Vikrant-B except one genotype *viz*., HB-504-C which showed lesser seed yield per plant than the check. On the other hand, rest of thirty one genotypes were found to be at par with check for this trait. Ammar et al. [3], Ahmed et al. [4] and Aziz and Osman [12] have also reported variation for seed yield per plant in their respective breeding material.

3.1.11 100-seed weight (g)

100-seed weight (g) is an important trait which contributes towards increased seed yield per plant. Genotypes HB-123-B (55.33), HB-613-A (53.81) and HB-65-B (53.65) were the top three and other eleven genotypes *viz*., HB-193-A, HB-123-C, HB-131-A, HB-43-A, Local-1-B, Local-2-B, HB-649-B, HB-65-A, HB-511-B, HB-115-B(Green) and HB-123-A showed significantly higher 100-seed weight than the check Vikrant-B whereas, nineteen genotypes were at par when compared with the check. The results are in agreement with those of Shrifi [11].

3.1.12 Pod yield per plant

Among all the characters studied pod yield is the most important because only on this trait the potential and marketing of genotype is determined. Significant variation was exhibited by all the genotypes for this trait. 'Local-1-C' was the top ranking genotype for pod yield per plant which significantly outperformed all the genotypes with an increase in yield of 30.83 per cent over check 'Vikrant-B'. In addition, fifteen genotypes produced pod yield similar to that of 'Vikrant-B'. HB-123-B, HB-123-C, HB-511-C, PRT-7-B, HB-40-A and HB-193-A were the top performing genotypes among them, while genotypes namely, HB-131-A, HB-43-A, DPFB-

2A, HB-131-B, HB-504-B, HB-193-C, HB-511-B (Brown) and ISV-10-2-C were at par and rest of eighteen genotypes have showed poor performance for pod yield per plant than the check. The superior performance of these genotypes for fresh pod yield per plant was mainly attributed to their superior/comparable performance for pods per node, nodes per plant, pod length, pods per plant, branches per plant, seed yield per plant, 100-seed weight to the check. These lines also exhibited better total soluble solids and ascorbic acid content.

3.2 Morphological Characterization

These genotypes were morphologically categorized on the basis of seed size and seed colour. In this context (Table 4), twenty five genotypes were having brown coloured seeds. In addition, two, three and five genotypes have

Table 4. Mean performance of 35 faba bean genotypes for quality traits

Trait Genotypes	Harvest index (per cent)	Total soluble (^{0}brix)	Ascorbic acid (mg/100 g)	Dry matter (per cent)	Protein content (per cent)
Local-2-A	22.91	8.07	18.44	13.48	21.34
HB-193-A	22.12	8.10	14.29	15.80	24.46
HB-40-A	25.83	8.10	19.44	14.09	20.40
HB-511-C	29.77	7.13	14.55	10.58	25.40
HB-123-C	31.44	8.20	13.69	13.73	17.59
HB-131-A	26.67	8.00	15.47	18.71	26.34
HB-43-A	20.84	6.90	12.70	14.24	19.47
HB-43-B	33.33	7.10	17.67	16.08	21.34
HB-123-B	28.34	7.50	14.31	15.40	19.47
Local-1-C	34.45	8.07	16.47	16.03	25.53
DPFB-2A	24.56	7.10	14.29	11.33	24.47
Local-1-B	25.17	8.05	15.47	18.24	23.84
HB-131-B	27.76	7.42	14.49	15.46	19.31
Local-1-A	22.92	6.97	15.87	17.34	19.78
HB-65-B	29.28	7.11	13.09	15.23	22.90
PRT-7-B	28.67	7.97	16.47	12.32	24.78
HB-504-B	24.94	7.67	15.47	11.86	16.34
HB-193-C	28.80	7.95	14.49	14.96	21.34
HB-115-D	29.09	8.05	15.61	12.80	24.53
HB-504-A	26.42	7.80	17.29	16.12	22.34
HB-115-B(Brown)	24.94	8.10	18.44	13.82	26.34
HB-193-B	20.89	7.10	12.70	16.12	17.76
HB-504-C	21.83	7.27	18.25	18.16	21.66
HB-115-A	25.67	7.05	14.29	15.33	15.40
HB-115-E	19.30	7.07	17.66	15.07	18.53
HB-613-A	20.97	7.93	15.47	13.96	22.54
Local-2-B	24.45	7.10	14.29	14.21	20.56
HB-649-B	22.86	7.05	12.70	18.25	24.01
HB-649-C	24.39	8.03	15.47	12.18	16.34
ISV-10-2-C	20.00	8.10	14.29	16.04	17.52
HB-65-A	22.10	7.23	19.44	16.35	22.26
HB-511-B	25.45	7.50	14.79	17.16	20.34
HB-115-B(Green)	21.03	6.30	17.27	17.34	16.34
HB-123-A	25.00	6.60	16.47	15.20	14.78
Vikrant-B (Check)	33.28	7.65	14.56	16.01	22.59
Range	19.30-34.45	6.30-8.20	12.70-19.44	10.58-18.71	14.78-26.34
Mean	25.59	7.53	15.59	15.11	21.08
SE(m) ±	2.262	0.060	0.169	0.070	0.198
CV (per cent)	15.269	1.381	1.886	0.810	1.627
CD (P ≤ 0.05)	6.397	0.169	0.479	0.198	0.56

SE(m) ±; Standard Error of mean; CV; Coefficient of variation' CD; Critical difference

light brown, green and black coloured seeds, respectively. The superior performing genotypes viz., HB-123-B, HB-123-C, HB-511-C, PRT-7-B, HB-40-A and HB-193-A had brown coloured seed. Most of the genotypes were found to have medium size (21 in number) while eight genotypes were found to have small and six were categorized into large seeded genotypes (Table 4).

3.3 Quality Traits

3.3.1 Harvest index (per cent)

Harvest index describes plant capacity to allocate biomass (assimilates) into the formed reproductive parts; Hence it is an important trait for plant breeding therefore, plant having high harvest index is widely accepted because of its tendency to produce more yield. Ten genotypes namely, Local-1-C, HB-43-B, HB-123-C, HB-511-C, HB-65-B, HB-115-D, HB-193-C, PRT-7-B, HB-123-B and HB-131-B were found to be statistically at par whereas, rest all twenty four genotypes showed significantly less per cent of harvest index than check Vikrant-B.

3.3.2 Total soluble solids (^{o}Brix)

The Total soluble solids measures and includes the carbohydrates, organic acids, proteins, fats and minerals of the seeds. Highest total soluble solid content were reported in HB-123-C (8.20) and lowest in HB-115-B (Brown) (6.30) with an overall mean of 7.53. Fourteen genotypes *viz*., Local-2-A, HB-193-A, HB-40-A, HB-123-C, HB-131-A, Local-1-C, Local-1-B, PRT-7-B, HB-193-C, HB-115-D, HB-115-B(Brown), HB-613-A, HB-649-C and ISV-10-2-C have significantly high total soluble solids whereas, four genotypes namely, HB-123-B, HB-131-B, HB-504-B and HB-511-B were at par with the check Vikrant-B.

3.3.3 Ascorbic acid (mg/100 g)

Nineteen genotypes *viz*., Local-2-A, HB-40-A, HB-131-A, HB-43-B, Local-1-C, Local-1-B, Local-1-A, PRT-7-B, HB-504-C, HB-115-D, HB-504-A, HB-115-B(Brown), HB-504-C, HB-115-E, HB-613-A, HB-649-C, HB-65-A, HB-115-B(Green) and HB-123-A showed significantly higher ascorbic acid content over check 'Vikrant-B'. Also, ten genotypes revealed similar performance to that of check Vikrant-B.

3.3.4 Dry matter (per cent)

Eight genotypes namely, HB-131-A, Local-1-B, Local-1-A, HB-504-C, HB-649-B, HB-65-A, HB-511-B and HB-115-B (Green) were found to be statistically superior for percent dry matter to the check Vikrant-B and five genotypes *viz*., HB-43-B, HB-193-A, HB-43-A, HB-504-A and HB-193-B have comparable percent dry matter as that of check 'Vikrant B'.

Table 5. Morphological characterization on basis of seed size and seed colour in thirty five genotypes of faba bean

Genotypes	Seed size (cm)	Seed colour
Local-2-A	Small	Brown
HB-193-A	Medium	Brown
HB-40-A	Medium	Brown
HB-511-C	Medium	Brown
HB-123-C	Medium	Brown
HB-131-A	Medium	Brown
HB-43-A	Medium	Brown
HB-43-B	Small	Brown
HB-123-B	Large	Brown
Local-1-C	Small	Brown
DPFB-2-A	Medium	Brown
Local-1-B	Medium	Brown
HB-131-B	Small	Brown
Local-1-A	Medium	Black
HB-65-B	Large	Brown
PRT-7-B	Medium	Brown
HB-504-B	Medium	Brown
HB-193-C	Small	Black
HB-115-D	Medium	Brown
HB-504-A	Small	Black
HB-115-B (Brown)	Medium	Brown
HB-193-B	Medium	Green
HB-504-C	Small	Brown
HB-115-A	Medium	Black
HB-115-E	Medium	Brown
HB-613-A	Large	Brown
Local-2-B	Large	Brown
HB-649-B	Medium	Brown
HB-649-C	Medium	Black
ISV-10-2-C	Medium	Brown
HB-65-A	Large	Brown
HB-511-B	Medium	Light brown
HB-115-B (Green)	Large	Green
HB-123-A	Medium	Light brown
Vikrant-7-B (Check)	Small	Brown

Limits: - 1.50-1.60- small size; 1.61-1.70- medium size; 1.71-1.80- large size

3.3.5 Protein content (per cent)

For protein content, ten genotypes *viz*., HB-193-A, HB-511-C, HB-131-A, Local-1-C, DPFB-2A, Local-1-B, PRT-7-B, HB-115-D, HB-115-B (Brown) and HB-649-B were the most superior genotypes which significantly outperformed the

check 'Vikrant-B'. Whereas, four genotypes HB-65-B, HB-504-A, HB-613-A and HB-65-A contained comparable protein content and twenty genotypes were recorded to have less percent of protein content as compared to check.

4. CONCLUSION

On the basis of mean performance, 'Local-1-C' was the top ranking genotype for pod yield per plant which significantly outperformed all the genotypes with an increase in yield of 30.83 per cent over check 'Vikrant-B'. Further, genotypes viz., HB-123-B and HB-123-C showed superiority for both pod yield and seed yield per plant over check and other genotypes. The superior performance for pod yield per plant and seed yield per plant was mainly attributed to their superior/comparable performance for pods per node, nodes per plant, pod length, pods per plant, branches per plant and 100-seed weight. The best performing genotypes could be used for further evaluation under different environments to be released as a variety (s) or under hybridization programmes for Broad bean improvement.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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