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Pre-Breeding Evaluation of Germplasm for Hybridization and Screening of Resulting Transgressive Elite Genotypes Faba Bean for Yield and its Attributes for Semi-Arid Regions of India

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ABSTRACT

A long term research investigation was carried out for identification of elite genotypes from germplasm and their utilization in the development of high yielding variety through hybridization followed by pedigree method to obtain desirable transgressive segregants of Faba bean at MAP Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar during winter season from 2004-18. In the present investigation, germplasm was screened for seed yield, resistance to biotic stress and other traits during 2004-05. As a result, ten elite genotypes were identified. By using these elite genotypes, forty five F_1 hybrids were developed during 2005-06 and from F_2 up to F_6 generations were evaluated to identify the superior progenies during 2006-11. Later on, the superior transgressive segregants entries were evaluated under various station trials from 2011-15 which led to identification of HB11-12, HB11-15 and HB11-32 as promising genotypes. Subsequently, these genotypes were further evaluated at different locations having diverse agro-ecological conditions for seed yield, quality and resistance against insect pest and disease during 2015-18. On the basis of average yield over all the locations, HB11-12 exhibited 14.95% yield superiority and was also found free from insect pests and disease. Hence, HB11-12 may be recommended for commercial cultivation in plain zones of semi arid regions of India.

***Keywords*:** Faba bean, pre-breeding, hybridization, transgressive segregants, vicine-convicine

Introduction

Vicia faba L. i.e. faba bean also know as broad beans or horse bean is the fourth most widely grown legume crop after pea, chickpea and lentil (FAOSTAT 2021; Maalouf et al. 2019). Grain legumes have been recognized to have advantages over cereals, both in human diet and agriculture (Foyer et al. 2016; Cooper et al. 2017). Faba bean (*Vicia faba* L.) belongs to the family Fabaceae, however, it is an often cross pollinated crop (Bishnoi et al. 2012). It is mainly grown as winter season crop and performs well under cool and moist conditions. It is important in crop rotation, as it fixes atmospheric nitrogen in the soil (Köpke and Nemecek, 2010) and is helpful in minimizing the requirement of chemical fertilizers resulting in improving the economics of the succeeding crops (Jensen et al. 2010; Arya, 2018; Arya et al. 2020), therefore, it reduces the environmental burden.

It is mainly used as animal feed in developed countries and also as food for human beings in developing countries. It has high nutritive value due to presence of high lysine, protein, vitamins, minerals and carbohydrates in its seeds (Crépon et al. 2010). Faba bean is gaining importance as a plant source of protein for humans and animals to ensure food and nutritional security at global level (Bishnoi et al. 2015; Multari et al. 2015).

Along with its different uses, potential of high seed production, balanced and high nutritional quality and ability to grow over a broad range of climatic and soil conditions makes faba bean an appropriate crop for sustainable agriculture due to which it has gained greater global attention in recent years (Köpke and Nemecek, 2010). However, its full potential through hybrid breeding still remains unexploited largely due to its unique pollination biology and yield instability (Bishnoi et al. 2015; Arya, 2018; Maalouf et al. 2019).

The process for development of new varieties in faba bean includes introduction and germplasm collection, pure line selection, single plant selection, selection and hybridisation with appropriate modifications (Singh and Bhatt 2012). The faba bean breeding programs revolves around improving yield, increasing resistance/tolerance to biotic and abiotic stresses, adaptation to the intended environment, suitable phenology, and seed quality. Conventional breeding in faba bean is performed by crossing elite parents, followed by multi-stage testing of progeny, identifying superior progeny with respect to specific traits and finally releasing superior varieties.

Moreover, nutritionally rich high yielding varieties resistant/tolerant to insect pests would not only be helpful in enhancing farm profitability (Maalouf et al. 2019) but also elevate the nutritional security. ICARDA has been working in this direction and also developed new cultivars of faba bean for commercial cultivation (Subash and Priya 2012). Therefore, keeping in view the above facts, the identification and utilization of elite genotypes for hybridization to develop high yielding varieties through transgressive segregation was planned.

Materials and Methods

Germplasm screening: In present investigation, 100 germplasm lines including national check Vikrant were screened for various agronomic traits under AICRN on Potential Crops in augmented block design with spacing of 45cm x 10 cm at Research Farm of Medicinal, Aromatic, and Potential Crops Section, Department of Genetics & Plant Breeding, CCS HAU, Hisar during winter 2004-05.

Hybridization and transgressive segregation: The transgressive segregation is the outcome of pedigree method, in which genetically diverse genotypes are crossed to combine different genes in one plant, and in later generations' up to F_6 these genes segregate in all possible combinations. An outstanding plant having superior performance over both the parent is the result of transgressive segregation. In present study, only identified elite genotypes (HB180, HB123, EC329675, EC47755, HB430, HB204, EC248710, PRT-12, HB85 and Vikrant) were utilized in crossing programme and 45 F_1 crosses were made during winter 2005-06 and F_1 seed was produced in next season. During winter 2007-08, F_2 progenies of all the crosses were grown and individual superior plants identified from the segregating populations were harvested separately. The F_3 to F_5 generations were also evaluated to identify the superior transgressive segregants through the process of critical selection or rejection during 2008-09 to 2010-11. Eventually, in F_6 generation, superior progenies of 14 crosses (Table 1) were bulked and evaluated in PRT for yield performance against the national check, Vikrant during 2011-12. Likewise, these genotypes were also evaluated in SST, LST and FYT at Hisar during 2012-13, 2013-14 and 2014-15, respectively. RBD (Randomized Block Design) with three replications at spacing of 30 cm x 10 cm in four rows of 3m each and the agronomic management i.e. NPK (kg/ha) 40:40:20 with four irrigations was used in SST, LST and FYT.

Multi-location trial: The superior genotypes so identified were further evaluated in multi-location trials at seven different locations having diverse agroclimatic conditions in various states of India i.e. Ambikapur (21°14'19.3"N and 81°42'17.5"E, Chhattisgarh), Delhi (28°37'48.2" and N 77°09'02.9"E, National Capital), Faizabad (26°32'26.3"N and 81°50'06.9"E, Uttar Pradesh), Faridkot (30°40'32.4"N and 74°44'56.7"E, Punjab), Hisar (29°08'56.7"N and75°41'35.9"E, Haryana), Ludhiana (30°54'06.9"N and 75°48'53.5"E, Punjab) and Ranchi (23°26'36.4"N and 85°18'53.4"E, Jharkhand) as shown in Figure 1 to identify the best performing high yielding varieties of faba bean for the plain zone of the country. Each genotype was planted in RBD with three replications at spacing of 30 cm x 10 cm in six rows of 3 m each and the same agronomic management i.e. NPK (kg/ha) 40:40:20 with four irrigations was used at all the locations.

Statistical analysis was carried out as per standard procedure (Sheoran et al. 1998).

Quality analysis: The seed samples were dried at 80°C for 8 hours and were ground to a fine powder. Crude protein content (%) was obtained by using micro-Kjeldahl method of AOAC (1984) (Hacıseferogulları et al. 2003). The vicine and convicine content were determined spectrophotometrically by using the method developed by Higazi and Read (1974).

Pathological study: All the faba bean genotypes were screened for their relative resistance/tolerance to Alternaria blight and root rot diseases under sick plot conditions in field at Research Area of Medicinal and Aromatic Plant Section, Department of Genetics and Plant Breeding, CCS HAU, Hisar during 2016-17 and 2017-18. Genotypes were sown in the second week of November in three replications of 4 m length and randomized block design was followed. Observation on per cent disease severity for Alternaria (Behairyet et al. 2014) blight and per cent disease incidence for root rot (Habtegebriel and Boydom, 2018) were recorded at flowering stage. Disease incidence and severity were calculated by the following formula:

$$\text{Disease incidence (\%)} = \frac{\text{Number of diseased plant}}{\text{Total number of plant}} \times 100$$

$$\text{Disease severity (\%)} = \frac{\text{Sum of all numerical ratings}}{\text{Total no. of leaves observed} \times \text{Maximum disease rating}} \times 100$$

After recording the disease incidence, the genotypes were grouped under following reaction categories:

Alternaria blight disease			Root rot diseases		
Disease score	Disease severity (%)	Reaction	Disease score	Disease incidence (%)	Rating
1	0-5	HR	1	0-5	R
2	6-10	R	2	6-15	MR
3	11-20	MR	3	16-25	S
4	21-30	MS	4	>26	HS
5	31-50	S			
6	>51	HS			

Insect pest damage study: The plants of all genotypes were examined weekly for presence of insects at various times of the day (Nuessly et al. 2004). Observations of feeding associations of Aphids and Stink Bugs with faba bean leaves, stems, flowers, and pods were recorded. Number of aphids, *Aphis craccivora*, per five plants was also recorded. Stink bugs including *Lygus lineolaris*, *L. heskerus* and *Nezara viridula* were counted per five plants. Percent pod borers were recorded by counting the number of damaged pods out of the total pods of five plants. Insects were identified to species where possible through the use of published systematic keys and direct comparisons with museum specimens of CCS HAU Hisar.

Results and Discussion

Germplasm evaluation: Before starting any breeding programme, generally, pre-breeding evaluation of germplasm lines is done to identify the desirable parents for different economic traits so that the enviable improvement could be achieved in shortest possible time. In the present investigation, 100 germplasm lines of faba bean were screened for yield and its contributing traits, biotic and abiotic stress, early maturing, shattering, and lodging against the national check, Vikrant during 2004-05 under AICRN on potential crops in augmented block design at Hisar. As a consequence, top 10 genotypes were identified with respect to above mentioned traits (Table 1).

Consequent upon the screening of 100 germplasm lines of faba bean, ten genotypes including check were identified for further hybridization program owing to their superior traits. The five genotypes HB 180, EC117755, HB430, HB204, and Vikrant were identified for higher seed yield. Similarly, genotype HB180 and HB85 had higher 100 seed weight. Likewise, HB123, EC117755, Vikrant were found to be highly tolerant to insect pests. Another yield contributing trait, number of pods per plant, was also considered and genotypes EC329675, HB204, EC248710, and PRT12 were found to be superior. Shattering remains a problem in faba bean resulting in direct losses in yield and contributes volunteer plants in the next cropping season. Therefore, the germplasm was screened for shattering tolerance and the genotypes HB180, and HB85 were identified. EC248710 was selected due to a unique characteristic of having short medium plant height and larger number of pods per plant.

Hybridization: In the present study, for integrating higher yield and resistance to biotic and abiotic stress, hybridization work was carried out among the identified superior genotypes/parents (HB180, HB123, EC329675, EC47755, HB430, HB204, EC248710, PRT12, HB85, and Vikrant) in all possible cross combinations through hand emasculation and pollination technique during 2004-05. However, success remained confined to 14 F_1 hybrids due to heavy dropping of crossed female flowers. The problem of abscission in buds, flowers and immature pods has been reported up to 89.5-92.5% by Rabie et al. (1991).

Generation advancement and selection of transgressive segregants: For advancement of generations, the plant progenies were evaluated for their growth, yield, and yield attributing characteristics as well as resistance to biotic and abiotic stress. In order to obtain homogenous and stable plant population, weak plants and progenies were discarded and only high yielding superior plant progenies were advanced. As the yield is affected by multiple environmental factors and management practices, therefore, these genotypes were evaluated for three consecutive years for yield and its contributing traits to realize their actual genetic potential under same management conditions. The resulting stabilized plant progenies were bulked and evaluated in Progeny Row Trial (PRT) for yield, its contributing traits and resistance to biotic and abiotic stress during winter 2011-12 (Table 2). The results revealed that the genotype HB11-2 has highest yield with seed yield 63.47 g/plant followed by HB11-15 (61.37 g/plant), HB11-12 (61.03 g/plant), HB11-32 (58.40 g/plant), HB11-3 (55.00 g/plant), HB11-4 (52.50 g/plant), HB11-5 (52.07 g/plant), HB11-18 (50.20 g/plant), HB11-1 (50.17 g/plant), HB11-9 (49.83 g/plant), HB11-13 (48.97 g/plant), HB11-20 (48.93 g/plant), Vikrant (45.55 g/plant), HB11-6 (45.27 g/plant) and HB11-14 (37.93 g/plant). The majority of genotypes were superior in yield performance against the national check Vikrant.

Performance in station trials: All the fourteen genotypes were promoted to station trials and evaluated for yield performance (Table 3) as well as its contributing traits for three years. In the small-scale trial (SST) during winter 2012-13, HB11-2 and HB11-12 produced maximum seed yield (4620 kg/ha) followed by HB11-15 (4520 kg/ha) and HB11-1 (4480 kg/ha). The large-scale trial (LST) was conducted during winter 2013-14 for second year evaluation of all the genotypes. The genotype HB11-12 produced highest seed yield (4639 kg/ha) followed by HB11-15 (4556 kg/ha), HB11-32 (4533 kg/ha), HB11-2 (4517 kg/ha) and HB11-18 (4394 kg/ha). In the next season, winter 2014-15, experiment was planned as final yield trial (FYT) to identify the promising genotype of faba bean against national check Vikrant. The highest yield was obtained from HB11-32 (4727 kg/ha) followed by HB11-12(4667 kg/ha), HB11-15 (4556 kg/ha), HB11-2(4400 kg/ha) and HB11-20(4378 kg/ha). Based on the three years results of station trials (Table 3), only the top performing genotypes viz., HB11-12 (4642 kg/ha), HB11-15 (4544 kg/ha) and HB11-32 (4513 kg/ha) were proposed for further testing of their yield performance at multiple locations having various agro-ecological conditions in coordinated trials.

Performance in coordinated trials: Upon establishing the yield potential at one location, the desired genotype should be tested at multiple locations over the years before releasing for commercial cultivation (Arya, 2018). The top performing genotypes viz., HB11-12 (4642 kg/ha), HB11-15 (4544 kg/ha) and HB11-32 (4513 kg/ha) over three years in station trials were further evaluated for their yield performance at multi-locations in coordinated trials.

The newly developed and the best performing genotypes viz., HB11-12, HB11-15 and HB11-32 along with the national check (Vikrant) were evaluated in coordinated trails at seven different locations viz., Ambikapur, Delhi, Faizabad, Faridkot, Hisar, Ludhiana and Ranchi in initial varietal trial (IVT) during 2015-16, and advanced varietal trial-I (AVT- I) during 2016-17 and advanced varietal trial-II (AVT-II) during 2017-18 (Yadav et al. 2016; 2017; 2018). During this period, observations were recorded on yield and its contributing traits, quality parameters and tolerance to insect pests and diseases.

The results of present investigation (Table 4) revealed that the performance of different genotypes varied over the years and locations due to differences in soil as well as climatic conditions. On the basis of average of three years (2015-16, 2016-17 and 2017-18, Figure 2), average seed yield of HB 11-12 was recorded as 2234 kg/ha against national check Vikrant (1959 kg/ha) with 14.95 per cent yield superiority in plain zone at national level.

Quality analysis: The nutritive value of faba bean crop is due to its higher protein content, however, presence of antinutritional factors, Vicine and Convicine impair the nutritional benefits when included in the daily diet (Gupta, 1987). Vicine and convicine, upon hydrolysis by β -glucosidase is converted to the aglycones divicine (2,6-diamino-4,5-dihydroxypyrimidine) and isouramil (6-amino-2,4,5-trihydroxypyrimidine), respectively. According to McMillan et al. (2001), the individuals having low-activity variant of erythrocytic glucose 6-phosphate dehydrogenase (G6PD) are susceptible to favism, a life-threatening hemolytic crisis, upon consumption of faba bean because of divicine and isouramil. G6PD regenerates the reduced glutathione resulting from reaction of NADPH in red blood cell hexose monophosphate shunt. G6PD deficient individuals are unable to regenerate reduced glutathione and so they are prone to the oxidative stress and ultimately hemolytic anemia (Arese et al. 2012), however, content of the antinutritional factors can be reduced fermentation process resulting in improving the nutritional quality of faba bean (Rizzello et al. 2016;

Polanowska et al. 2020). Keeping in view the above factors, in the present investigation, protein (%), and vicine-convicine (%), contents were analysed for the three top performing genotypes *i.e.* HB11-12, HB11-32, HB11-15 against the check, Vikrant (Table 5). The average protein content over two years in HB11-12, HB11-32, and HB11-15 was recorded 23.54, 23.48, and 24.14, respectively. The mean vicine-convicine content (%) over two years was 0.73 in HB11-12 and followed by HB11-32 (0.74) and HB11-15 (0.76%).

Plant pathology: The pathology study revealed HB-11-12 showed moderately resistant reaction against Alternaria and root rot diseases (Table 6), however, it need to be tested for their authenticity with other inoculation techniques and thereafter it can be utilized in resistance breeding programme for at least development of tolerant variety of faba bean (Juroszek, and von Tiedemann, 2011). The genotypes, HB-11-32 and HB-11-15 showed moderately susceptible reaction against Alternaria blight and susceptible reaction against root rot diseases. However, the genotype, HB-11-12 showed moderately resistant reaction against Alternaria blight and root rot diseases and may be utilized for commercial cultivation. Among the tested genotypes, HB11-32 and HB11-12 showed minimum infestation of pods, moreover, the infestation and damage by insect pests was below economic threshold level. This indicates that insect pests *Aphis craccivora, Lygus lineolaris*, *L. heskerus* and *Nezara viridula* have lower preference towards these genotypes.

The new genotype, HB11-12 of faba bean has been developed as result of transgressive segregation of cross, EC117755 x HB180. It was evaluated over the years at multiple locations and found promising in seed yield other attributing traits. It is also rich in protein content and comparable antinutritional, vicine-convicine content. HB11-12 was also found moderately resistant to Alternaria blight and root rot disease, and insect infestation was also below the economic threshold level. Therefore, it is concluded that HB11-12 may be recommended for commercial cultivation in plain zones of semi arid regions of India.

Insect pest damage study: Minimum population of Aphids, *Aphis craccivora*, appeared on the genotypes HB 11-32 (4.50 nymphs/5 plants) and it was statistically at par with HB 11-12 (4.75 nymphs/5 plants). The population of stink bugs was also recorded on the crop in the month of March 2017. Stink bugs includes *Lygus lineolaris*, *L. heskerus,* and *Nezara viridula*. Minimum population these bugs was recorded on HB-11-32, and HB 11-12. Percent pod borers were recorded by counting the number of damaged pods out of the total pods of five plants (Table 7). Minimum infestation of pods was recorded in the genotype, HB 11-32 (4.50%) and it was statistically at par with HB-11-12 (4.75%).

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Table 1. Performance of top 10 genotypes with respect to different traits.

No.	Parent	Distinct Characters Identified
1.	HB180	Higher seed yield, green pod yield, 100 seed weight, protein. Moderately tolerant to shattering
2.	HB123	Creamy white flower, light green seeds, highly tolerant to insect pests
3.	EC329675	Tall plant with more number of pods per plant
4.	EC117755	Higher seed yield, highly tolerant to insect pests and diseases
5.	HB430	Higher seed yield
6.	HB204	Higher seed yield and larger number of pods per plant
7.	EC248710	Short-medium plant height, larger number of pods per plant
8.	PRT12	Medium plant height, larger number of pods per plant
9.	HB85	Tolerant to shattering and salinity, higher in 100 seed weight
10.	Vikrant	Good yield, Tolerant to insect pests, diseases, lodging

Table 2. Performance of transgressive segregants of faba bean obtained from F_1 hybrids in Progeny Row Trial at Hisar during 2011-12.

No.	New Genotypes	Pedigree Details	Days to Maturity	Plant Height (cm)	Number of Pods/ Plant	Seed Yield/ Plant (g)
1	HB11-1	HB180 × HB 123	166.67	105.53	51.00	50.17
2	HB11-2	Vikrant × HB 123	158.00	98.57	66.33	63.47
3	HB11-3	EC329675 × Vikrant	155.33	96.60	65.67	55.00
4	HB11-4	EC117755 × Vikrant	170.00	115.97	64.67	52.50
5	HB11-5	EC117755 × HB123	153.33	94.17	54.67	52.07
6	HB11-6	EC117755 × HB430	151.00	91.40	48.67	45.27
7	HB11-9	HB204 × HB123	167.67	94.37	53.00	49.83
8	HB11-12	EC117755 × HB180	155.00	93.00	57.00	61.03
9	HB11-13	EC117755 × HB 204	169.00	114.33	52.00	48.97
10	HB11-14	HB430 × HB123	154.00	93.67	41.33	37.93
11	HB11-15	EC329675 × HB 180	170.00	114.00	58.67	61.37
12	HB11-18	EC248710 × Vikrant	169.67	103.50	53.00	50.20
13	HB11-20	EC117755 × PRT-12	168.33	112.60	53.67	48.93
14	HB11-32	HB85 × Vikrant	167.00	113.87	64.67	58.40
15	Vikrant	National check	165.00	106.90	37.67	45.55
	Mean		162.67	103.23	54.80	52.05
	CD (p = 0.05)		6.82	7.06	0.35	7.99
	CV (%)		2.56	4.17	3.91	10.60

Table 3. Seed yield performance of newly developed elite genotypes in station trials.

No.	New Genotypes	Seed Yield Performance (kg/ha)			
		SST, 2012-13	LST, 2013-14	FYT, 2014-15	Over All Mean
1	HB11-1	4480	4222	3461	4054
2	HB11-2	4620	4517	4406	4512
3	HB11-3	4380	4111	3611	4034
4	HB11-4	4280	4028	3611	3973
5	HB11-5	4210	3944	3628	3927
6	HB11-6	4030	2978	2889	3299
7	HB11-9	4340	4278	4217	4278
8	HB11-12	4620	4639	4667	4642
9	HB11-13	4380	4333	4239	4317
10	HB11-14	4100	3183	3250	3511
11	HB11-15	4520	4556	4556	4544
12	HB11-18	4380	4394	4306	4360
13	HB11-20	4200	4250	4378	4276
14	HB11-32	4280	4533	4727	4513
15	Vikrant (c)	3600	3556	3333	3496
	Mean	4295	4001	3952	4116
	CD (p = 0.05)	36.0	24.6	34.5	-
	CV (%)	55.0	35.8	52.5	--

Table 4. Seed yield performance of newly developed elite genotypes in coordinated trials.

No.	Genotypes	Seed Yield Performance (kg/ha)							
		Ambikapur	Delhi	Faizabad	Faridkot	Hisar	Ludhiana	Ranchi	Mean
IVT Winter 2015-16									
1.	HB11-12	1047	1375	2750	3368	4566	1733	1294	2305
2.	HB11-15	826	1265	2667	3542	4063	1733	1394	2213
3.	HB11-32	685	1253	2648	3316	4611	1833	1264	2229
4.	HB-11-38	647	970	2858	3385	3993	1967	1145	2138
5.	Vikrant (c)	1032	1581	2828	3507	3434	1800	1143	2189
	Mean	765	1138	2849	3432	3650	1720	1242	2012
	CD (p=0.05)	218	436	598	355	247	206	119	-
	CV (%)	193	2184	1196	676	257	693	650	-
AVT-I Winter 2016-17									
1	HB11-12	1792	1384	2777	2785	4573	2083	1935	2476
2	HB11-15	1729	1523	2975	2423	3779	2222	2120	2396
3	HB11-32	1682	1464	2650	3183	4708	2118	1663	2498
4	Vikrant (c)	1728	1247	2858	3002	3590	1840	1390	2136
	Mean	1707	1326	2672	2826	4065	1987	1900	2240
	CD (p = 0.05)	120	225	472	695	181	253	94	-
	CV (%)	509	226	109	144	302	728	336	-
AVT-II Winter 2017-18									
1	HB11-12	871	762	2889	-	3864	1458	1678	1920
2	HB11-15	868	1358	2727	-	4089	1493	2140	2113
3	HB11-32	627	837	2481	-	3874	1354	1943	1853
4	Vikrant (c)	655	651	2130	-	2983	1510	1390	1553
	Mean	735	881	2500	-	3709	1516	1982	1889
	CD (p = 0.05)	178	267	415	-	309	169	120	-
	CV (%)	139	177	974	-	489	657	419	-

Table 5. Faba bean protein and vicine convicine content (%).

No.	Genotypes	Protein Content (%)			Vicine-Convicine (%)		
		2015-16	2016-17	Mean	2015-16	2016-17	Mean
1.	HB 11-12	23.70	23.37	23.54	0.74	0.72	0.73
2.	HB 11-32	23.83	23.13	23.48	0.72	0.75	0.74
3.	HB 11-15	23.80	24.47	24.14	0.75	0.76	0.76
4.	Vikrant	25.10	24.80	24.95	0.79	0.80	0.80
	Mean	24.11	24.53	24.32	0.75	0.77	0.76

Table 6. Screening of faba bean against Alternaria leaf blight and root rot disease.

No.	Genotypes	Alternaria Blight (% Severity)			Disease Reaction	Root Rot Incidence (%)			Disease Reaction
		2016-17	2017-18	Mean		2016-17	2017-18	Mean	
1	HB-11-12	19.25	16.0	17.63	MR	13.25	11.2	12.23	MR
2	HB-11-32	24.75	26.5	25.63	MS	20.00	22.4	21.20	S
3	HB-11-15	18.25	21.2	19.73	MS	24.50	26.6	25.55	S
4	Vikrant	16.50	22.2	19.35	MS	24.25	14.6	19.43	MR

Table 7. Entomological data of promising genotypes in the advanced varietal trial 2016-17.

No.	Genotypes	Aphids/5plants	Stink Bugs / 5plants	% Pod Damage
1	HB11-12	4.75 (2.40)	4.75 (2.40)	4.25
2	HB11-32	4.50 (2.37)	4.50 (2.37)	4.00
3	HB11-15	7.75 (2.98)	7.75 (2.98)	8.75
4	Vikrant	11.00 (3.47)	9.50 (3.24)	9.25
	SE(m)	0.454	0.428	
	C.D. (p = 0.05)	1.343	1.267	

Note: Figures in parentheses are √n+1 value.

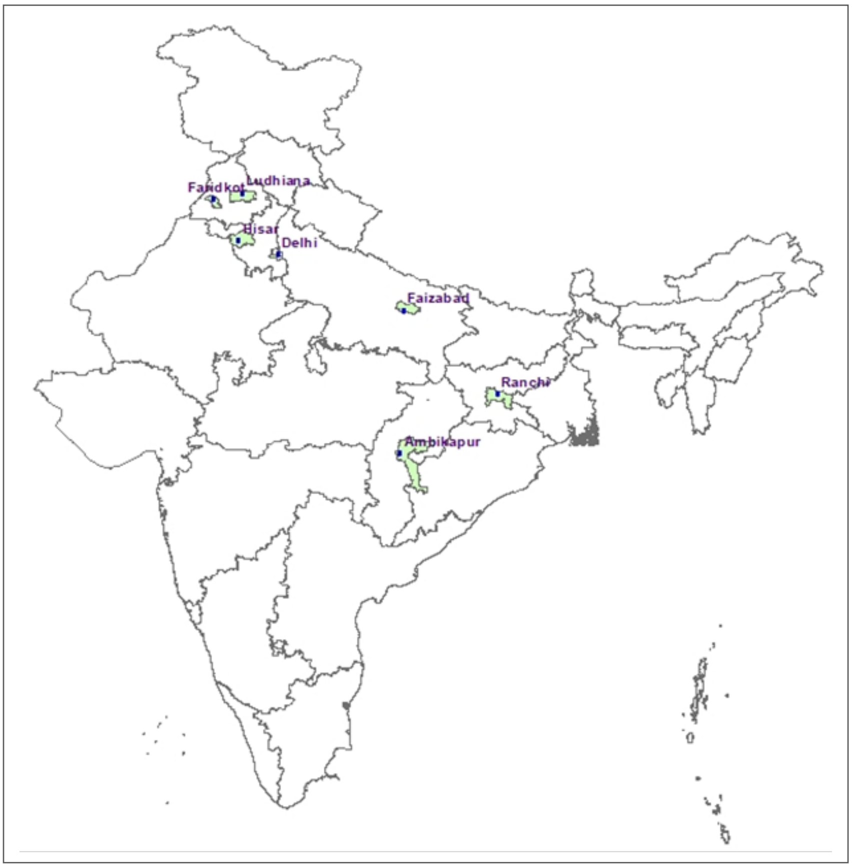

Figure 1. Map showing experimental locations of faba bean trials in plain zones having different agro-climatic conditions of India.

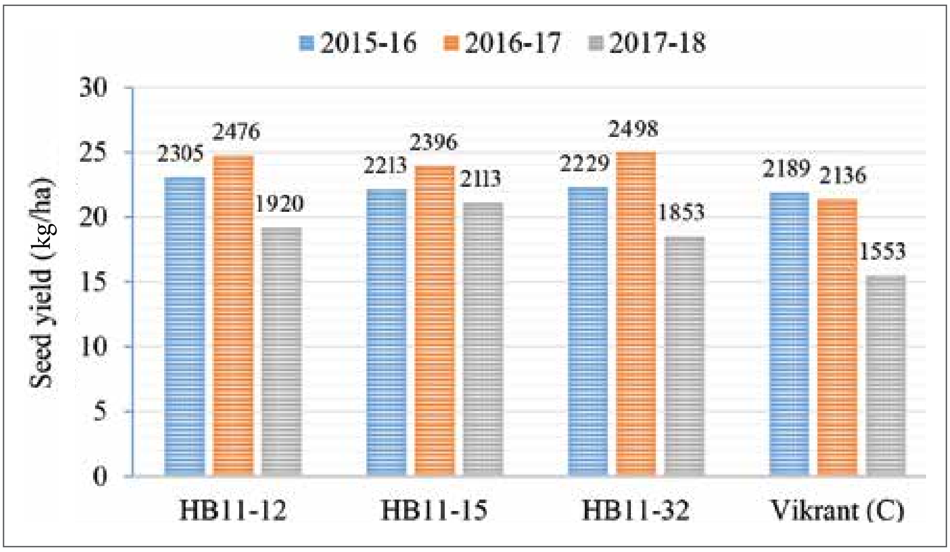

Figure 2. Seed yield performance of faba bean promising genotypes during 2015-16, 2016-17, 2017-18.

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