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Comparative evaluation of common bean (*Phaseolus vulgaris* L.) germplasm for seed physical and culinary traits

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Abstract

The amount of water absorbed during soaking by dry beans before cooking may be a reliable indicator of the amount of time required to render them soft and palatable to eat. The present study was undertaken in kharif 2012 at Regional Research Station Wadura. Fifty diverse germplasm accessions (local and exotic) representing different growth habits and market classes were compared with Shalimar Rajmash-1, a high yielding bush variety released by SKUAST-K, for 12 seed morphological and physical characters namely seed colour, seed brilliance, seed shape, seed coat pattern, dry seed weight, soaked seed weight, seed length, seed breadth, seed coat proportion, water absorption ratio, hydration capacity and swelling capacity. There was a broad range of variation in the traits studied as revealed by the range and coefficient of variation (%). The CV was highest for swelling capacity (18.62) followed by water absorption (16.281), hydration capacity (13.61), soaked seed weight (10.712), dry seed weight (3.056) and coat proportion (1.221). However, CV was very low for seed length and seed breadth owing to low variation in these traits. The correlation between different traits was also worked out and revealed that highest correlation was recorded between dry weight and soaked weight (0.874) followed by hydration capacity and swelling capacity (0.720), seed dry weight and hydration capacity (0.710), dry weight and water absorption (0.308), indicating that the seeds with greater cotyledon mass absorbed more water and that greater water absorption leads to greater swelling. However, negative correlations were recorded between coat proportion and water absorption (-0.550) and between dry weight and coat proportion (-0.325). Seed physicochemical traits including the traits used in present study could be effectively used for comparing large set of germplasm lines for cooking qualities as the varieties that have high hydration and swelling capacities are usually fast to cook.

Key words: Common bean, hydration capacity, swelling capacity, water absorption

Introduction

Common bean (*Phaseolus vulgaris* L.) is one of the most important pulse crop in India. It is regarded as "Grain of hope" as it is an important component of subsistence agriculture and feeds about 300 million people in tropics and 100 million people in Africa alone. Besides it is emerging as an important income generation especially in Central America where beans are No. 1 income generators among field crops. Globally, with 21 million tonnes produced from about 26 million hectares, it accounts for about half of the total pulse production. In India, common bean is grown over an area of about 6 million hectares with a production of about 2.5 million tones (FOA, 2010). In Kashmir valley common bean is a niche crop relished for its taste and is an integral part of culture and agriculture. Dry mature seeds provide a relatively greater amount of higher quality protein ranging from 17 to 32% which makes them an excellent complement for diets rich in cereals (Moraghan and Grafton, 2001). Therefore, beans have a major role in human diet especially in developing countries where they are considered a low cost protein source. The quality of beans especially the cooking time, taste and freedom from flatulence are key parameters for consumer acceptability as well as marketability of common bean varieties. The proceedure of evaluation of common bean genotypes for cooking time by CIAT in Cali, Colombia, is based on a cooking time index derived from a bardrop cooker (Jackson and Varriano-Marston, 1981). Although a useful and reliable technique, it is laborious and time consuming for large number of samples. It has been suggested that the amount of water dry beans absorb during soaking before cooking may be a reliable indicator of the amount of time required to render them soft and palatable to eat. Hence, the water absorption of a genotype may be a useful and rapid indirect selection method to screen germplasm for cooking time. A large number of studies have been undertaken to asses the variation among the genotypes for various seed traits including water absorption for screening material for seed culinary properties (Krista and Hosefield, 1991; Santalla *et al.*, 1999 and Vakali *et al.*, 2009). The present study was undertaken to asses the variation in seed morphological and physical characteristics in selected common bean genotypes in Kashmir valley in view of the fact that the niche status of this valuable crop is more due to its cooking quality and taste than its production potential. A large number of genotypes have been identified for their yielding ability but their acceptance by farmers will depend on their quality parameters especially the physical appearance and culinary properties.

Materials and methods

The present study was undertaken in *Kharif* 2012 at Regional Research Station Wadura. About 750 germplasm accessions of common bean were evaluated in an augmented block design in view of large number of accessions (data not presented). Fifty diverse germplasm accessions (23 local landraces, one released variety and 26 exotic accessions procured from CIAT (Columbia), NORDIC (Sweden) and IPK (Germany), representing different growth habits and market classes were selected for the present study. The performance of the genotypes was compared with Shalimar Rajmash-1 (SR-1), a high yielding bush variety released by SKUAST-K, for 12 seed morphological and physical characters namely seed colour, seed brilliance, seed shape, seed coat pattern, dry seed weight, soaked seed weight, seed length, seed breadth, seed coat proportion, water absorption ratio, hydration capacity and swelling capacity. Seed water absorption parameters were calculated as per the procedure of Bishnoi and Khetarpaul (1993) as follows.

Dry and soaked seed weight: The dry seed weight as well as soaked seed weight were computed on 100 seed basis.

Coat proportion: Seed coat proportion was determined on 20 seeds per plot, as the weight ratio between coat and cotyledon expressed in percentage, after removing the seed coat from the cotyledons, both after soaking and keeping them for 24 h at 105 °C.

Water absorption ratio: Measured as the amount of water which the dried seeds absorbed during soaking for 24 hours in double distilled water. The moisture contents of the dry bean samples were equilibrated before analysis of water absorption by storing them for 2 weeks in sealed plastic containers at ambient temperatures and relative humidity. The percent water absorption was determined by first soaking 30 seeds for 24 h in distilled water at room temperature and dividing the difference in weight before and after soaking by the dry weight of the 30-seed sample.

Swelling coefficient: All the seed samples were used two months after harvesting. Bean samples (50 g per variety) were soaked in double distilled water for 24 h at room temperature. After soaking, the increase in water volume was recorded and the swelling coefficient was determined as the percentage ratio of increase in the volume of water in bean seeds both before and after hydration.

Hydration capacity: The hydration capacity was expressed as hydration absorption per seed and was determined by dividing the mass gained from seeds by the number of seeds present in sample (g of water per g of seeds).

Swelling capacity: The swelling capacity per seed was calculated as the volume gained from the seeds (mL of water per g of seeds) divided by the number of seeds.

The results were analysed through OPSTAT software developed by CCS HAU, Hisar for assessment of variation and trait correlations in the material studied.

Results and discussion

The accessions selected for the present study were purposefully included to represent the diverse market classes and the most of the accessions represented common landraces being cultivated across diverse niches of the crop. The accessions represented diversity of different morphological seed characteristics such as seed colour, seed brilliance, seed shape and seed coat pattern (Table 1). Most of the accessions were brown and red with brilliant seeds, mostly kidney shaped and plain seed coat.

Perusal of Table 2 reveals the variation in mean performance for six seed traits related to consumer acceptability and culinary properties. Highest dry seed weight (100 seed basis) was observed in WB-457 (74.45 g) and lowest was recorded in WB-245 (22.60 g). Highest soaked weight was recorded for WB-440 (167.80 g) whereas the lowest was recorded for WB-245 (29.80 g). Coat proportion was lowest in WB-195 (8.17 %) and highest in WB-46-2 (25.14 %). Water absorption was highest in WB-195 (183.09 %) and lowest in WB-75 (17.53 %). Similarly, hydration capacity was highest in WB-457 (1.02 g water/g seed) and lowest in WB-245 (0.07 g water/g seed). Swelling capacity was highest in g water/g seed195 (1.56 mL/g seed) and lowest in WB-75 (1.03 mL/g seed).

Frequency distribution graphs (Fig. 1) in respect of water absorption %, hydration capacity and swelling capacity revealed that most of the genotypes (41) had water absorption capacity ranging from 40-120 %. Only seven genotypes had water absorption capacity above 120%. Similarly in case of hydration capacity, 31 genotypes had hydration capacity ranging from 0.3-0.7 and only two genotypes had hydration capacity above 0.7. In case of swelling, 45 genotypes had swelling capacity in the range of 0.97-1.37 and only one genotype had swelling capacity above 1.5. The graphs in case of water absorption % and hydration capacity were fairly normal while as in case of swelling capacity, it was skewed (Fig. 1).

There was a broad range of variation in the traits studied as revealed by the range and coefficient of variation (Table 3). The CV was highest for swelling capacity (18.62) followed by water absorption (16.281), hydration capacity (13.61), soaked seed weight (10.712), dry seed weight (3.056) and coat proportion (1.221). However, CV was very low for seed length and seed breadth owing to low

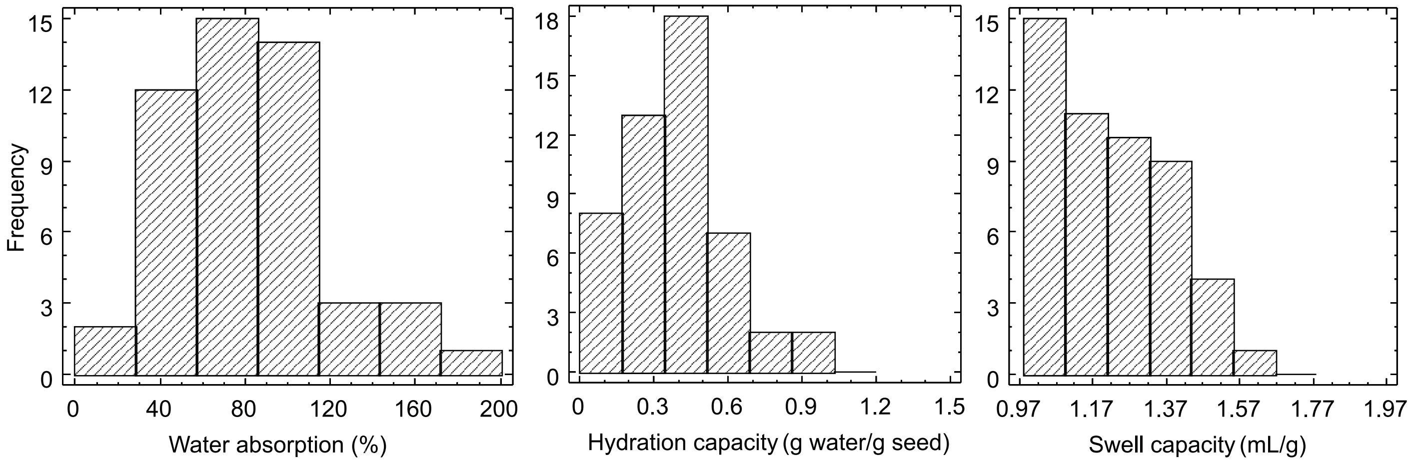

Fig. 1. Frequency distribution of water absorption, hydration capacity and swelling capacity among the bean accessions

Table 1. Origin, pedigree and variability in seed morphological traits in common bean

Accession	Pedigree	Origin	Colour	Brilliance	Shape	Coat pattern
WB-6	G-51420	Columbia	Red	Brilliant	Oval	Plain
WB-22	G-51416	Columbia	Red	Brilliant	Kidney	Plain
WB-30	PHA-12327	Columbia	Cream	Medium	Oval	Plain
WB-46-2	PAS-65-1	Tral	Black	Brilliant	Kidney	Mottled
WB-46-3	PAS-65-2	Tral	Purple	Brilliant	Kidney	Plain
WB-67	G-3601	USA	Red	Brilliant	Kidney	Plain
WB-75	PAS-174	Khag	Brown	Dull	Cuboidal	Plain
WB-83	PAS-193	Baramulla	Purple	Brilliant	Cuboidal	Plain
WB-93-1	BG-22512	Spain	Black	Brilliant	Kidney	Plain
WB-112	PAS-110	Pulwama	Purple	Brilliant	Kidney	Plain
WB-131	PAS-54	Uri	Brown	Medium	Kidney	Plain
WB-195	PAS-11	Baramulla	Choclate	Brilliant	Kidney	Plain
WB-216	RB-39	Nigeria	Pink	Medium	Kidney	Plain
WB-245	PAS-248	Poonch	Brown	Brilliant	Cuboidal	Mottled
WB-250	PAS-226	Baramulla	Red	Brilliant	Oval	Mottled
WB-257	PAS-256	Baramulla	Red	Brilliant	Kidney	Plain
WB-261	PAS-261	Kishtwar	Red	Medium	Cuboidal	Plain
WB-360	PHA-12663	Turkey	White	Brilliant	Kidney	Plain
WB-363	PHA-13576	Russia	Chocolate	Brilliant	Cuboidal	Plain
WB-368	PHA-12645	Turkey	White	Medium	Cuboidal	Plain
WB-380	PHA-12707	Holland	Brown	Medium	Kidney	Plain
WB-413	PHA-5942	Ukraine	Brown	Brilliant	Kidney	Mottled
WB-439	PHA-12202	Russia	Brown	Medium	Oval	Mottled
WB-440	PHA-7140	Spain	Brown	Medium	Kidney	Plain
WB-441	PHA-12266	Russia	Brown	Medium	Kidney	Mottled
WB-444	PHA-7549	Spain	White	Brilliant	Kidney	Plain
WB-455	PHA-7141	Spain	White	Brilliant	Kidney	Plain
WB-457	PHA-13575	Russia	Brown	Medium	Kidney	Mottled
WB-467	NG-13964	Sweden	Brown	Brilliant	Kidney	Plain
WB-485	NG-21237	Sweden	Chocolate	Dull	Kidney	Mottled
WB-497	NG-13858	Sweden	Yellow	Brilliant	Kidney	Plain
WB-874	PAS-450	Baramulla	Red	Medium	Oval	Mottled
WB-893	PAS-469	Budgam	Black	Brilliant	Kidney	Plain
WB-923	PAS-499	Baramulla	Brown	Medium	Kidney	Mottled
WB-931	G-37	Canada	white	Brilliant	Oval	Mottled
WB-943	G-370	Turkey	Purple	Brilliant	Kidney	Mottled
WB-951	G-558	Turkey	Purple	Brilliant	Kidney	Plain
WB-954	G-678	Syria	Purple	Brilliant	Kidney	Plain
WB-956	G-680	Syria	White	Brilliant	Kidney	Plain
WB-966	G-1295	Columbia	Red	Brilliant	Kidney	Plain
WB-970	G-1426	Ukraine	Cream	Brilliant	Kidney	Plain
WB-1006	PAS-521	Baramulla	Chocolate	Brilliant	Kidney	Mottled
WB-1035	EB-7	Nepal	Brown	Brilliant	Kidney	Plain
WB-1146	PAS-657	Baramulla	Brown	Medium	Kidney	Plain
WB-1181	PAS-707	Kupwara	Yellow	Brilliant	Cuboidal	Plain
WB-1182	PAS-708	Kupwara	Brown	Dull	Kidney	Plain
WB-1184	PAS-710	Kupwara	Yellow	Brilliant	Kidney	Plain
WB-1185	PAS-711	Kupwara	Brown	Medium	Kidney	Plain
WB-1186	PAS-712	Kupwara	Cream	Brilliant	Kidney	Plain
SR-1	CR x Local red	Released variety	Red	Brilliant	Kidney	Plain

variation in these traits. Compared to the relased variety SR-1, most of the accessions had desirable attributes of the eight seed traits studied. Variability in seed physical traits and culinary traits have also been reported by various workers (Krista and Hosefield, 1991; Santalla *et al.*, 1999 and Vakali *et al.*, 2009) in common bean using coat proportion and water absorption as indicative traits.

The correlation between different traits (Table 4) revealed that highest correlation was recorded between dry weight and soaked weight (0.874) followed by hydration capacity and swelling capacity (0.720), seed dry weight and hydration capacity (0.710), wet weight and swelling capacity (0.588), dry weight and water absorption (0.308) indicating that the seeds with greater cotyledon mass absorbed more water and that greater water absorption

Table 2. Mean performance for eight seed characteristics in common bean

Entry	Dry weight (g)	Wet weight (g)	Seed length (cm)	Seed breadth (cm)	Coat percentage (%)	Water absorption (%)	Hydration capacity (g water/g seed)	Swell capacity (mL/g)
WB-6	45.77	80.88	1.40	0.95	22.25	54.86	0.35	1.05
WB-22	52.65	75.20	1.50	0.70	15.95	42.83	0.22	1.09
WB-30	45.35	84.40	1.50	1.00	12.79	86.11	0.39	1.22
WB-46-2	40.85	67.60	1.55	0.80	25.14	73.16	0.27	1.19
WB-46-3	36.70	58.80	1.35	0.70	13.60	57.49	0.22	1.03
WB-67	46.25	106.60	1.60	0.75	13.51	130.7	0.60	1.43
WB-75	30.80	36.20	1.30	0.80	15.33	17.53	0.05	1.03
WB-83	31.85	40.10	1.10	0.80	18.45	25.90	0.08	1.15
WB-93-1	40.10	56.60	1.30	0.70	10.60	41.14	0.16	1.19
WB-112	32.30	54.80	1.55	0.70	19.71	51.08	0.22	1.17
WB-131	46.20	87.40	1.60	0.85	13.73	89.17	0.43	1.27
WB-195	35.50	90.50	1.60	0.70	8.17	183.09	0.55	1.56
WB-216	37.85	93.20	1.50	0.90	14.16	119.81	0.55	1.37
WB-245	22.60	29.80	1.30	0.70	20.71	31.85	0.07	1.01
WB-250	45.30	85.60	1.20	0.70	16.12	88.96	0.40	1.14
WB-257	56.35	94.20	1.65	0.80	11.67	60.07	0.38	1.10
WB-261	35.15	47.60	1.40	0.80	16.78	35.41	0.12	1.03
WB-360	64.25	103.42	2.00	1.00	22.41	60.93	0.39	1.08
WB-363	37.85	55.20	1.25	0.80	19.92	45.84	0.17	1.04
WB-368	44.57	87.40	1.15	1.00	9.84	96.09	0.43	1.33
WB-380	36.50	48.60	1.60	0.70	22.35	33.15	0.12	1.06
WB-413	61.80	99.40	1.65	0.90	11.67	60.84	0.38	1.11
WB-439	62.40	124.40	1.30	1.15	14.14	99.35	0.62	1.36
WB-440	65.65	167.80	1.75	1.00	10.13	155.59	1.02	1.44
WB-441	66.75	139.40	1.90	0.90	10.76	108.83	0.75	1.23
WB-444	57.60	115.80	1.90	1.00	15.19	101.04	0.58	1.26
WB-455	56.70	96.50	1.80	0.75	16.16	70.19	0.40	1.08
WB-457	75.40	162.70	1.90	1.00	12.70	115.78	0.87	1.47
WB-467	28.20	47.40	1.20	0.65	14.34	68.08	0.21	1.22
WB-485	43.45	61.40	1.50	0.80	15.63	41.31	0.18	1.24
WB-497	53.20	130.20	1.55	0.80	11.52	144.73	0.77	1.55
WB-874	36.45	92.06	1.30	0.75	12.29	152.56	0.56	1.46
WB-893	35.95	56.80	1.25	0.80	13.38	57.99	0.21	1.17
WB-923	53.50	103.20	1.50	0.70	14.73	92.89	0.50	1.28
WB-931	51.35	94.70	1.30	1.00	19.01	84.42	0.43	1.09
WB-943	54.95	99.20	1.75	0.90	14.31	80.52	0.48	1.41
WB-951	59.10	107.60	1.75	0.85	9.10	80.37	0.48	1.36
WB-954	42.55	75.40	1.60	0.85	12.99	77.20	0.33	1.18
WB-956	42.45	88.20	1.60	0.75	14.74	107.77	0.46	1.25
WB-966	53.15	99.40	1.55	0.90	10.86	87.01	0.46	1.05
WB-970	41.25	60.15	1.50	0.70	14.29	45.81	0.19	1.02
WB-1006	35.35	75.40	1.40	0.80	14.06	113.29	0.40	1.38
WB-1035	52.85	106.80	1.70	0.90	13.11	102.08	0.54	1.33
WB-1146	38.80	69.20	1.40	0.70	10.69	78.35	0.31	1.26
WB-1181	47.10	86.80	1.20	0.85	9.21	83.43	0.39	1.10
WB-1182	32.80	42.85	1.50	0.65	19.51	30.64	0.10	1.08
WB-1184	34.55	68.00	1.15	0.65	13.23	96.81	0.33	1.12
WB-1185	43.90	80.04	1.40	0.80	13.99	82.32	0.36	1.22
WB-1186	27.30	53.20	1.55	0.60	10.15	94.87	0.26	1.34
SR-1	49.75	67.90	1.65	0.70	18.85	36.43	0.18	1.08

Table 3. Mean, range and CV (%) for eight seed culinary traits

Trait	Mean	Range	CV (%)
Dry seed weight (g)	43.939	22.60 - 66.75	3.06
Soaked seed weight (g)	77.793	29.8 - 167.80	10.71
Seed length (cm)	1.483	1.10 - 2.00	0.03
Seed breadth (cm)	0.804	0.60 - 1.15	0.02
Coat proportion (%)	13.764	2.70 - 25.14	1.22
Water absorption (%)	70.984	25.90 - 154.92	16.28
Hydration capacity (g water/g seed)	0.316	0.07 - 1.02	13.81
Swelling capacity (mL/seed)	1.204	1.01 - 1.56	18.63

Table 4. Correlation between eight seed traits in common bean

Correlation between traits	Correlation coefficient
Dry weight and wet weight	0.874**
Dry weight and coat proportion	-0.325**
Dry weight and water absorption	0.308**
Coat proportion and water absorption	-0.550**
Coat proportion and hydration capacity	-0.561**
Hydration capacity and swelling capacity	0.720**
Seed dry weight and hydration capacity	0.710**
Seed dry weight and swelling capacity	0.245
Wet weight and swelling capacity	0.588**

leads to greater swelling. However, negative correlations were recorded between coat proportion and water absorption (-0.550) and between dry weight and coat proportion (-0.325). The negative correlation between the traits as reported above is due to the fact that seeds with thicker seed coats are invariably impermeable to water and impede water imbibition by dry seeds during soaking process. Mavromatis *et al.* (2012) also made a comparative study in common bean for seed physicochemical traits and concluded that these traits could be effectively used for comparing large set of germplasm lines for cooking qualities as the varieties that have high hydration and swelling capacities are usually fast to cook (Jackson and Varriano-Marston, 1981; Castillo *et al.*, 2008). However, the lines that have lower hydration and swelling capacities usually have longer storage life.

The present study revealed significant variation among the bean accessions for seed quality traits. The variation can be utilized through selection to identify high yielding genotypes with better seed culinary traits. The correlations identified in the study can be used to develop effective selection index in view of the diversity and complexity of seed quality traits.

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