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Evaluation of Bush type Common Bean (*Phaseolus vulgaris* L.) Genotypes under Cold Arid Ladakh Conditions

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ABSTRACT

In the present study, we evaluated a set of 21 bush type common bean genotypes for their adaptability, performance of yield and maturity as well as phenology based biomass partitioning in Leh Ladakh.. In terms of seed colour, six genotypes were red in colour, five were brown, four genotypes were white, two purple and one each was pink, yellow and chocolate in colour. For seed shape, 12 genotypes were Kidney shaped, 3 each were cylindrical, cuboidal and oval. Seed coat pattern revealed that 15 genotypes were having plain seed coat pattern and 6 had mottling of variable colours and intensities. Out of 21 genotypes, six were large, 13 were medium and two were small. WB-257 was earliest to flower whereas WB-1690 was late to flower. WB-956, WB-195 and WB-811 matured earlier whereas WB-1690 was late maturing. Highest pod length was recorded in case of WB-185 followed by WB-1492 whereas lowest value was recorded in case of WB- 6. Highest value for 100-seed weight was recorded in case of WB-966 followed by WB-216 and lowest value recorded for Arka Anoop. Seed yield measured on per plant basis was highest in case of WB-185 followed by WB-1643 and lowest in case of Arka Anoop. Analysis of variance for the traits studied revealed that mean squares due to genotypes were significant for all the traits. Seed growth rate and economic growth rate were highest in WB-185 followed by WB-1643 and WB-1492 and lowest in case of WB-1129. Seed yield was positively correlated with economic growth rate, seed growth rate, pod length and 100-seed weight, while as it was negatively correlated with days to maturity and days to seed fill. Economic growth rate was positively correlated with seed growth rate and pod length, but was negatively correlated with days to maturity and days to seed fill.

Keywords: *Common bean, Ladakh, biomass partitioning, correlation*

ABBREVATIONS: DF: Days to flowering, DM: Days to maturity, PH: Plant height, PL: Pod length, NOSPP: Number of seeds per pod, 100SW: 100-seed weight, DSF: Days to seed fill, SGR: Seed growth rate, EGR: Economic growth rate, SYPP: Seed yield per plant

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INTRODUCTION

Ladakh is a land locked cold arid valley of Jammu and Kashmir state falling in western Himalayas. Out of the total geographical area of 45167 hectares only about 10156 hectares are cultivated with a cropping intensity of around 100%. Wheat and alfalfa are major crops of the region and pulses are grown on just 300 hectares with a meagre productivity of 585 kgs/ha [4]. With the soils mostly sandy loams having low water retention capacity, pulse crops such as common bean that have deep roots and utilise water efficiently can be a major component of the farming system in Ladakh. Moreover, the crop is nutritionally rich and a cheap source of protein and other essential nutrients. Common bean (*Phaseolus vulgaris*) known as *Rajmash* is the most important summer season pulse crop of Kashmir valley. It is an indispensable component of the diets as well as the farming system. In the Jammu & Kashmir state, it enjoys a niche status among the crops on account of its being a cheap source of protein, minerals and nutraceuticals. It is also a substantial contributor to the income of the subsistence farmers as it fetches better prices than cereals. Common bean is regarded as a nearly perfect food as it contains balanced mixture of different nutrients that promote better health and fight certain diseases. However, due to disappointingly low yield of pulses, they have become less competitive and people mostly prefer wheat and other crops. Therefore, in order to diversify the farming system, it is essential to identify high yielding

varieties of rajmash that can perform better under Ladakh conditions.. This would require characterisation of germplasm for its adaptability and yielding ability in Ladakh.
The success of any breeding programme depends on the presence of sufficient variability to pursue effective selection. Therefore the study of genetic variability and its effective utilization is a fundamental tool for crop improvement programmes. Ample germplasm resources are available in form of farmer's adapted landraces, advanced breeding lines, collections in national and international gene banks which can be used for identification and development of high yielding bean cultivars. A number of studies have been conducted to characterize the variability in common bean for yield and morphological traits to develop pre-breeding material for appropriate breeding strategies for developing high yielding varieties [11, 6].
Yield is the final outcome of the all the physiological and mechanistic efficiency of plants. Therefore various yield contributing traits and biomass accumulation and partitioning indices based on phenology that indicate efficiency of resource acquisition and remobilisation are used to identify productive genotypes. There is growing evidence substantiated by experimental data that biomass partitioning can be used as effective selection criteria for analyzing productivity in different crops including common beans. There can be substantial and stable differences between species and varieties in the patterns of dry matter allocation [5] and these differences can be clearly related to crop performance. In the present study, we evaluated a set of 20 bush type common bean genotypes along with one check Arka Anoop developed by ICAR-IIHR, Bengaluru for their adaptability, performance of yield and maturity as well as phenology based biomass partitioning.

MATERIAL AND METHODS

Location: The present study was undertaken during 2017 in the research farm of High Mountain Arid Agriculture Research Institute, SKUAST-K at Leh (altitude of 3319 metres above sea level).
Plant material: The material comprised of 21 bush type genotypes of common bean belonging to diverse maturity and market classes (comprising local landraces a well as accessions procured from national and international gene banks) including a check variety Arka Anoop released by IIHR, Bangalore.
Experimental set up: The material was evaluated in Randomized complete block design (RCBD) with three replications. Each genotype was represented by a plot size of 2 x 2 meter dimensions with 5 lines. The plants were space planted for optimal expression of traits. Days to flowering and days to maturity were measured on plot basis whereas above ground biomass and seed yield was measured on five competitive plants from each replication under both water stressed and well watered conditions. The following biomass partitioning indices (Ramirez-Vallejo and Kelly, 1998) were used for genotypic differentiation for response to water stress. Data was analysed for ANOVA using OPSTAT-1 (CCS HAU, Hisar). Correlations were worked out using XLSTAT (Addinsoft Corp.)

Index	Formula	Relevance
Days of seed fill (DSF)	DSF =DM - DF	Measures the time period that is used by plant to accumulate and remobilise photosynthates after flowering
Economic growth rate (EGR)	EGR= Seed yield/DM	Measures the daily growth rate of the economic product viz. seed yield
Seed growth rate (SGR)	SGR = Seed yield/DSF	Measures the growth rate of seed biomass post fertilisation.

RESULTS AND DISCUSSION

The general descriptive features of the genotypes are presented in table 1. All the genotypes used in the present study were determinate bush types as common bean is invariably grown as a sole crop. Out of the 21 genotypes, 12 were exotic (procured from NBPGR, CIAT Columbia and IPK Germany) and 8 were local landraces. In terms of seed colour, six genotypes were red in colour, five were brown, four genotypes were white, two purple and one each was pink, yellow and chocolate in colour. For seed shape, 12 genotypes were Kidney shaped, 3 each were cylindrical, cuboidal and oval. Seed coat pattern revealed that 15 genotypes were having plain seed coat pattern and 6 had mottling of variable colours and intensities. Out of 21 genotypes, six were large (seed weight > 4g), 13 were medium (seed weight 2.5-4g) and two were small (seed weight < 2.5g). The results indicated diversity of market classes in the material evaluated in terms of seed size, shape and colour.
Mean performance of genotypes for morphological and yield traits is given in table 2. Perusal of the table revealed that WB-257 was earliest to flower (55.667) whereas WB-1690 (84.667) took the highest number of days to flower. For days to maturity, results showed that WB-956 (106.333) WB-195 and WB-811 (108.667) matured earlier whereas WB-1690 (132.00) was late maturing. Plant height was highest in case of WB-1690 (41.200) followed by WB-216 (37.667) and lowest in case of Arka Anoop (23.433).

Highest pod length was recorded in case of WB-185 (12.100) followed by WB-1492 (10.773) whereas lowest value was recorded in case of WB- 6(8.500). Seeds per plant had highest value in case of WB-1129 (5.600) followed by WB- 185 (5.533) and lowest value in case of WB-966 (3.167). Similarly, highest value for 100-seed weight was recorded in case of WB-966 (49.431) followed by WB-216 (43.604) and lowest value recorded for Arka Anoop (21.712). Seed yield measured on per plant basis was highest in case of WB-185 (12.567) followed by WB-1643 (9.000) and lowest in case of Arka Anoop (5.400). Based on CD values, it could be safely concluded that the lines were significantly different from each other for various traits studied. Sofi *et al* [10], Sofi *et al* [9] and Iram Saba *et al* [6] have also reported significant variability for morphological and yield traits in common bean germplasm tested under Kashmir valley condition. Analysis of variance (Table 3) for the traits studied revealed that mean squares due to genotypes were significant for all the traits studied indicating presence of substantial variability in the lines evaluated that can be used to develop high yielding rajmash genotypes for Ladakh region.

The phenology based biomass partitioning based on days to flowering and maturity (Days to seed fill, seed growth rate and economic growth rate) are presented in table 4. Days to seed fill was highest in WB-257 (55.333) followed by WB-6 (54.333) and Arka Anoop (52.666) while as lowest value was recorded in WB-662 (38.666). Seed growth rate was highest in WB-185 (0.285) followed by WB-1643 (0.226) and WB-1492 (0.216) and lowest in case of WB-1129 (0.096). Similarly, economic growth rate was highest in case of WB-185 (0.115) followed by WB-1643 (0.081) whereas lowest value was recorded in case of WB-1129 (0.039). Acosta-Gallegos [1] and Ramirez Vallejo and Kelly [8] have also reported the usefulness of phenology based biomass partitioning indices as indicators of crop performance under different environmental conditions. in fact the differential yielding ability is more related to the ability of plants to effectively partition the accumulated photosynthates post fertilisation towards the sink.

Correlation matrix seed yield, phenology based partitioning indices and other yield parameters are given in table 5. Seed yield was positively correlated with economic growth rate (0.986), followed by seed growth rate (0.955), pod length (0.478) and 100-seed weight (0.363), while as it was negatively correlated with days to maturity (-0.459) and days to seed fill (-0.408). The number of pods per plant and 100-seed weight have been reported to be positively correlated with yield as these variables are key determinants of yield [3]. Positive correlation of seed yield with pods per plant and seeds per pod has also been reported by Ambachew *et al*., [2] and Khalid Rehman [7]. Similarly, economic growth rate was positively correlated with seed growth rate (0.968) followed by pod length (0.524), but was negatively correlated with days to maturity (-0.596) and days to seed fill (-0.472). Seed growth rate was positively correlated with pod length (0.468), but was negatively correlated with days to seed fill (-0.640) and days to maturity (-0.569). Number of seeds per pod was positively correlated with pod length (0.498). Similar relationship between yield and yield and phenology based indices have been reported by Acosta-Gallegos [1], Ramirez Vallejo and Kelly [8] and Khalid Rehman [7].

Table 1: General description of genotypes used in the study

Genotype	Origin	Growth habit	Seed colour	Seed shape	Seed coat pattern	Seed size
WB-966	Exotic	Bush	Red	Kidney	Mottled	Large
WB-335	Exotic	Bush	White	Oval	Plain	Medium
WB-1129	Local	Bush	Brown	Cylindrical	Plain	Medium
WB-1435	Exotic	Bush	Black	Oval	Plain	Medium
WB-216	Exotic	Bush	Pink	Kidney	Plain	Large
WB-719	Exotic	Bush	Red	Cuboidal	Plain	Medium
WB-22	Exotic	Bush	Purple	Cylindrical	Plain	Large
WB-1643	Exotic	Bush	Brown	Cuboidal	Mottled	Medium
WB-1690	Local	Bush	Brown	Cylindrical	Plain	Small
WB-811	Local	Bush	Brown	Kidney	Mottled	Medium
WB-1441	Exotic	Bush	White	Kidney	Mottled	Medium
WB-1247	Local	Bush	Red	Cuboidal	Plain	Medium
WB-185	Exotic	Bush	Red	Kidney	Plain	Large
WB-956	Exotic	Bush	White	Kidney	Mottled	Medium
WB-662	Local	Bush	Yellow	Kidney	Plain	Medium
WB-252	Local	Bush	Brown	Kidney	Plain	Medium
WB-1492	Exotic	Bush	Purple	Kidney	Mottled	Medium
WB-195	Local	Bush	Chocolate	Kidney	Plain	Medium
WB-6	Exotic	Bush	Red	Oval	Plain	Large
WB-257	Local	Bush	Red	Kidney	Plain	Large
Arka Anup	Check	Bush	White	Kidney	Plain	Small

Table 2: Mean performance of 21 common bean genotypes for morphological and yield parameters

Genotype	DF	DM	PH (cm)	PL (cm)	NOSPP	100-SW (g)	SYPP (g)
WB-966	74.667	121.667	26.333	9.333	3.167	49.431	7.467
WB-335	73.333	120.667	25.267	9.000	4.400	36.013	6.270
WB-1129	71.667	122.333	24.267	10.500	5.600	28.021	4.867
WB-1435	66.333	111.667	29.433	9.500	3.867	36.763	8.367
WB-216	75.333	122.000	37.667	10.800	3.733	43.604	6.300
WB-719	71.667	119.333	27.933	9.667	4.000	32.437	6.167
WB-22	75.000	118.667	26.767	9.367	4.200	43.007	8.233
WB-1643	70.667	110.333	27.333	9.733	4.933	32.558	9.000
WB-1690	84.667	132.000	41.200	9.333	4.867	22.703	5.720
WB-811	66.333	108.667	30.267	10.167	4.533	36.765	8.300
WB-1441	70.667	113.000	28.500	9.800	4.000	37.231	6.367
WB-1247	70.000	114.333	30.167	9.967	3.867	33.411	6.400
WB-185	64.667	108.667	30.400	12.100	5.533	40.230	12.567
WB-956	66.333	106.333	29.967	10.200	3.467	37.613	7.067
WB-662	71.667	110.333	23.333	10.067	3.400	29.406	5.633
WB-252	64.667	109.000	25.833	10.000	4.867	27.422	6.533
WB-1492	71.000	110.000	34.733	10.733	5.133	29.233	8.433
WB-195	66.000	108.667	27.000	10.133	4.533	32.516	5.533
WB-6	70.000	124.333	28.700	8.500	3.400	40.067	5.400
WB-257	55.667	111.000	37.133	10.567	4.333	40.033	6.367
Arka Anup	69.667	122.333	23.433	10.167	5.000	21.712	5.400
Mean	70.001	115.492	29.317	9.982	4.325	34.771	6.971
CD	10.237	1.900	2.415	1.060	0.601	0.894	0.508

Table 3: Analysis of variance for morphological and yield parameters in 21 common bean genotypes

Source of variation	df	DF	DM	PH	PL (cm)	NOSPP	100-SW (g)	SYPP (g)
Replication	2	57.333	6.682**	3.860	0.022	0.762**	1.045**	0.168
Genotypes	20	94.567*	145.187**	68.510**	1.693**	1.505**	144.424**	9.113**
Error	40	38.200	1.316	2.126	0.410	0.132	0.291	0.094

Table 4: Phenology based biomass partitioning indices in 21 common bean genotypes

Genotype	Days to seed fill	Seed growth rate (g/day)	Economic growth rate (g/day)
WB-966	47.000	0.158	0.061
WB-335	47.334	0.132	0.052
WB-1129	50.666	0.096	0.039
WB-1435	45.334	0.184	0.075
WB-216	46.667	0.135	0.051
WB-719	47.666	0.129	0.052
WB-22	43.667	0.188	0.069
WB-1643	39.666	0.226	0.081
WB-1690	47.333	0.121	0.043
WB-811	42.334	0.196	0.076
WB-1441	42.333	0.150	0.056
WB-1247	44.333	0.144	0.056
WB-185	44.000	0.285	0.115
WB-956	40.000	0.176	0.066
WB-662	38.666	0.145	0.051
WB-252	44.333	0.147	0.060
WB-1492	39.000	0.216	0.076
WB-195	42.667	0.129	0.051
WB-6	54.333	0.099	0.043
WB-257	55.333	0.115	0.057
Arka Anup	52.666	0.102	0.044

Table 5: Correlation matrix for morphological and yield parameters in 21 common bean genotypes

Trait	DF	DM	PH (cm)	PL (cm)	NOSPP	100-SW (g)	DSF	SGR	EGR	SYPP (g)
DF	-	0.730**	0.125	-0.400*	-0.080	-0.165	-0.112	-0.160	-0.337	-0.221
DM		-	0.170	-0.463**	-0.047	-0.138	0.597**	-0.569**	-0.596**	-0.459**
PH (cm)			-	0.211	0.041	-0.061	0.100	0.072	0.077	0.115
PL (cm)				-	0.498**	0.255	-0.204	0.468*	0.524**	0.478**
NOSPP					-	-0.241	0.026	0.248	0.273	0.275
100-SW						**-**	-0.007	0.277	0.331	0.363*
DSF							-	-0.640**	-0.472*	-0.408*
SGR								-	0.968**	0.959**
EGR									-	0.986**
SYPP (g)										-

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