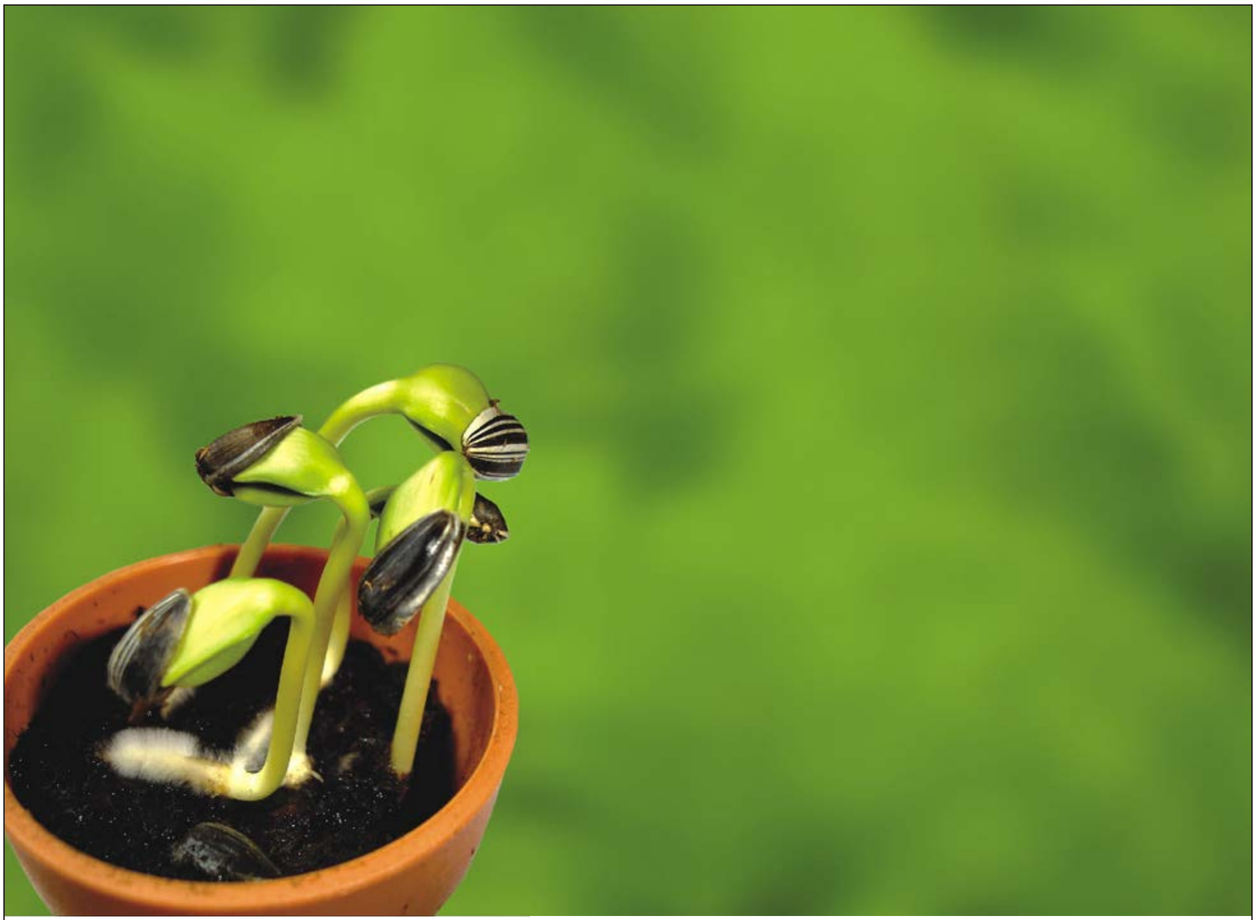

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Genetic Variability in Snap Bean (*Phaseolus vulgaris* L.) Genotypes in Central Rift Valley of Ethiopia

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ABSTRACT

Snap bean is an important crop in Ethiopia and its production has been steadily increasing. It occupies the highest share (94%) of export potential among all vegetables. Despite its importance, limited research effort was made to improve yield, pod quality to export market standard and tolerance to diseases. Thus, the present study was conducted to estimate the extent and pattern of genetic variability, heritability and genetic advance expected under selection to be used in the future breeding programs. Thirty six snap bean (*Phaseolus vulgaris* L.) genotypes were tested in 6×6 simple lattice designs at Melkassa Agricultural Research Center in 2010 in the off-season using furrow irrigation. Data on yield and yield contributing traits were collected. Significant difference among the genotypes for most of the characters was observed. High phenotypic coefficient of variation was recorded for green pod yield and other yield contributing traits. Similarly, green pod yield per plant depicted high genotypic coefficient of variation while pod number per plant, single green pod weight and green pod width showed medium genotypic coefficient of variation. High to medium heritability coupled with high expected genetic advance as percent of mean was observed for green pod yield and pod number per plant indicating the opportunity to improve these characters through selection. Generally, the present study entails the presence of genetic variability among the test genotypes with respect to the traits under investigation. This implies the opportunity to bring about green pod yield improvements in snap bean either through direct selection or hybridization.

Key words: Snap bean (*Phaseolus vulgaris* L.), genetic variability, heritability, genetic advence

INTRODUCTION

Snap bean (*Phaseolus vulgaris* L.) comprises a group of common bean that has been selected for succulent pods with reduced fiber which primarily grown for its young, edible, fleshly pods. The immature pods and seeds are produced and marketed fresh, canned or frozen products (Abate, 2006). The crop is widely cultivated due to its good source of fiber. Its immature edible pod and ripe seeds contain protein, carbohydrate, fat, fiber, thiamine, riboflavin, calcium and iron.

As a cash crop, snap bean is produced worldwide for export and canning industries. In Ethiopia, different plant types (bush/pole) of diverse pod characters (bobby/fine bean) of the crop are produced for export purposes. Its production has been steadily increasing due to the involvement of state horticultural enterprises, local and foreign private investors and farmers (Dessalegn, 2003) and thus occupies the highest share (94%) of export potential among all vegetables (Dessalegn *et al.*, 2006; Dessalegn, 2011). In the last five years, there has been 12 fold increase of export potential. Besides its export value, the crop is becoming important in local markets, big hotels, festivals and in making various dishes (Dessalegn *et al.*, 2006).

Despite the importance of the crop in the country, limited research effort was made to improve yield, pod quality to export market standard and tolerance to diseases (IDEA, 2001). Hence, varieties under production are low in yield, susceptible to rust and does not meet the export pod quality standards (Dessalegn *et al.*, 2006). Thus, estimation of the extent and pattern of genetic variability existing in the available accessions of the crop is essential to utilize in the future breeding programs (Scossiroli *et al.*, 1963). Utilization of genetic resources as a source of variability also requires their systematic evaluation. Therefore, the present study was conducted to estimate the extent of genotypic and phenotypic variability, heritability (in the broad sense) and genetic advance expected under selection.

MATERIALS AND METHODS

Experimental site: The experiment was conducted at Melkassa Agricultural Research Center (MARC) in 2010 (at the end of Aug. to Dec.) using furrow irrigation. The site is situated in major snap bean growing belts which is 117 km South East of Addis Ababa with geographic co-ordinate of 8°24'N latitude and 39°12'E longitude at an altitude of 1550 m.a.s.l. The mean annual rainfall of the area is 763 mm and the mean annual maximum and minimum temperature is about 28.6 and 13.8°C, respectively. The soil texture is dominantly loam and clay loam (Tesfaye *et al.*, 2009) and is slightly alkaline ranging from 7.4 to 7.6 pH an optimum range for availability of major nutrients (Mesfine *et al.*, 2005).

Experimental materials: The experimental materials in the present study consisted of thirty six snap bean genotypes originally obtained from CIAT and FAO. Simple lattice design (6×6) was employed where each plot consisted of two rows with length of 4 m and width 0.8 m that makes a total area of 3.2 m^2. The spacing was 40 and 10 cm between rows and plants, respectively. Fertilizer rate of 100 kg ha^{-1} DAP and 50 kg ha^{-1} urea was applied. All other necessary cultural practices were applied to all plots uniformly as per the recommendation of snap bean production in the country (MARC, 2004). Data regarding days to 50% emergence, days to 50% flowering, days to first picking, vegetative growth, yield and yield contributing traits were collected (Table 1).

Data analysis: Data were subjected to Analysis of variance as per the procedure for simple lattice design as described by Gomez and Gomez (1984) using SAS version 9.2 (SAS, 2008). It is appropriate to apply incomplete block designs like simple lattice design in single factor experiments where the number of treatments was very large. DMRT (Duncan's Multiple Range Test) was also used for mean separation procedures as the number of treatments used in the experiment was large. The genotypic and phenotypic variances and coefficients of variation were computed as per the methods of Burton and DeVane (1953), broad sense heritability as described by Allard (1960) and Fehr *et al.* (1987), Genetic Advance (GA) and GA as percent of the mean (GA%) as illustrated by Fehr *et al.* (1987) using GENRES soft ware program version 7.01.

Table 1: Analysis of variance for 16 quantitative characters of 36 snap bean genotypes evaluated using simple lattice design at Melkassa Agricultural Research Centers in 2010

		Mean squares						
Source of variation	DF	LN	LA	PH	PB	SB	NN	IN
Replication	1	0.5339	5632.10	44.33	0.6050	0.2812	0.08	0.134
Treatment (unaj.)	35	43.089	85440.00	231.02	0.2157	0.0721	4.30	3.39
Treatment (aj.)	35	37.864*	84502.00*	213.15**	0.1649^{ns}	0.0632^{ns}	3.92**	3.10**
Block with in replication	10	35.038	37854.00	12.33	0.2092	0.0480	3.92	1.11
Intra block error	25	14.089	42207.00	15.63	0.1081	0.0464	0.41	0.91
CV (%)		18.900	26.77	9.90	9.9000	15.4000	6.72	10.66
R^2		72.500	70.80	94.60	63.3000	64.9000	92.30	83.40
Efficiency relative to RCBD		120.000	97.05	93.97	102.1000	100.7000	104.34	101.00

		Mean squares								
Source of variation	DF	DE	DFW	DFP	PDW	PL	GPW	PWD	GPN	GPY
Replication	1	0.2222	10.1250	4.5000	0.04109	0.8339	2.1287	7.8672	175.160	170.82
Treatment (unaj.)	35	1.2143	9.5372	23.6175	0.01253	2.8816	0.6951	3.3705	92.900	1442.36
Treatment (aj.)	35	1.0300*	8.530**	22.7500**	0.01145^{ns}	2.8509**	0.6539**	3.3057**	95.183*	1441.87**
Block with in rep	10	0.6390	1.3970	4.2170	0.00244	0.6302	0.2160	0.9119	63.806	720.01
Intra block error	25	0.5156	1.9338	5.4133	0.007286	1.8186	0.1457	0.5406	42.225	436.61
CV (%)		9.3000	3.3000	4.1000	20.00000	6.7600	11.0000	9.4000	22.500	18.70
R^2		73.4000	86.0000	85.0000	70.60000	83.0000	86.5000	86.3000	72.300	77.80
Efficiency relative to RCBD		100.3000	91.9400	93.6800	80.90000	95.3400	101.3000	107.1600	104.000	105.16

**Significant at 1%, *significant at 5% and ns: Non significant, DF: Degree of freedom, LN: Leaf number per plant, LA: Leaf area per plant (cm^2), PH: Plant height (cm), PB: No. of primary branches per plant, SB: No. of secondary branches, NN: No. of nodes on main stem, IN: No. of internodes on main stem. DE: Days to 50% emergence, DFW: Days to 50% flowering, DFP: Days to first picking, DPW: Single dry pod weight (g), GPW: Single green pod weight (g), PL: Green pod length (cm) , PW: Green pod width (cm), GPN: No. of green pod per plant, GPY: Green pod yield per plant (g)

RESULTS AND DISCUSSION

The mean square values of 14 quantitative characters from ANOVA are presented in Table 1. Most of the characters except primary branches per plant, single pod dry weight and secondary branches showed highly significant ($p<0.01$) and significant differences ($p<0.05$) among the test genotypes indicating the presence of adequate genetic variability which can be exploited through selection. Similarly, Das (2005) reported considerable variability for traits such as plant height, primary branches per plant, secondary branches, days to 50% flowering, green pod width, green pod length, pod number and green pod yield per plant in snap bean genotypes.

The range and mean values for the 16 characters studied are presented in Table 2. The mean performance of the 36 snap bean genotypes for 16 traits is presented Table 3. The mean pod number per plant ranged from 8.75 for genotype PHA-5783/93 to 38.75 for genotype Tema. About 52.8% of the genotypes gave above the grand mean (25.1 pods per plant). Similarly, Joshi and Mehra (1983) reported a range of 6-37 pod numbers per plant in snap bean germplasm. The mean green pod yield per plant ranged from 31.85 g for genotype PHA-5783/93 to 145.95 g for genotype HAB-423. Concerning green pod yield per plant, 38.9% of the genotypes gave above the grand mean (85.3 g). Singh *et al.* (2000) also reported a range of 49 to 147.33 g green pod yield per plant in snap bean genotypes.

With regard to plant height, the mean range was from 25.4 to 78 cm. A mean range of 3.3 to 4.95 and 1.15-2.05 was observed among the genotypes for number of primary branches per plant and secondary branches, respectively (Table 2). Similarly, Joshi and Mehra (1983) also recorded a range of 3 to 5 primary branches per plant in the same crop.

The mean number of days to 50% flowering ranged from 38 days for genotype PHA-5780/93 and PHA-5782/93 to 47 days for genotype PHA-22. For days to first picking, the mean number of days for first picking ranged from 49 days for genotype PHA-5782/93 to 62 days for genotype PHA-22. With regard to these phenological characters, 38.9% of the genotypes had taken more number of days to flowering compared to the grand mean (42.1 days) while 36.1% of the genotypes had taken more number of days for first harvest compared to the grand mean (53.8 days) (Table 2). Similarly, Singh *et al.* (2000) reported a range of 43 days to 53 days for days to 50% flowering.

Estimates of phenotypic (σ^2P) and genotypic (σ^2g) variances and phenotypic (PCV) and genotypic (GCV) coefficient variation are given in Table 2. GCV was less than its corresponding estimates of PCV for all traits which indicated significant role of the environment in the expression of these traits. According to Sivasubranian and Menon (1973), GCV and PCV values were considered to be low (0-10%), medium (10-20%) and high (>20%). Accordingly, the PCV was low for days to 50% flowering (5.65%) and days to first picking (7.03%) while high for green pod yield per plant (36.89%), pod number per plant (34.12%), leaf area per plant (32.45%), plant height (28.17%), leaf number per plant (23.69%) and dry pod weight (22.52%). Medium PCV was observed for single green pod weight (19.19%), node and inter node number on main stem (17.76%), pod

Table 2: Estimates of range, mean, genetic components of variance, heritability and genetic advance as percent of mean of snap bean genotypes evaluated at Melkassa Agricultural Research Centers in 2010

Traits	Range	Mean	σ^2g	σ^2p	GCV (%)	PCV (%)	H	GA (%)
1	17.65-47.400	23.78±0.93	11.340	31.750	14.56	23.69	0.357	17.42
2	402.10-130200	774.7±41.63	22234.000	3197.850	19.25	32.45	0.352	23.52
3	25.40-78.050	39.2±1.840	108.410	123.100	26.43	28.17	0.881	51.09
4	3.30-4.9500	4.2±0.070	0.021	0.194	3.48	10.47	0.111	2.39
5	1.15-2.0500	1.48±0.04	0.021	0.059	7.68	16.49	0.217	7.38
6	8.10-13.250	9.68±0.26	1.910	2.390	14.28	15.97	0.800	26.31
7	7.10-12.250	8.6±0.260	1.210	2.380	15.89	17.76	0.800	29.29
8	6.50-10.000	8.88±0.16	0.310	0.900	6.89	11.76	0.3432	8.32
9	38.00-47.000	42.09±0.40	3.830	5.660	4.68	5.65	0.685	7.98
10	49.00-62.000	53.86±0.63	9.270	14.340	5.65	7.03	0.645	9.36
11	2.45-4.9500	3.41±0.02	0.265	0.430	15.05	19.19	0.613	24.31
12	0.235-0.575	0.40±0.11	0.004	0.008	16.11	22.52	0.512	23.74
13	9.53-14.020	12.51±0.22	1.080	1.800	8.31	10.72	0.601	13.29
14	7.5-13.2000	8.66±0.24	1.360	2.010	13.47	16.35	0.678	22.85
15	8.75-38.750	25.1±1.240	23.700	72.200	19.55	34.12	0.328	23.08
16	31.85-145.95	85.27± 5.21	452.880	989.500	24.96	36.89	0.458	34.78

1: Leaf No. per plant, 2: Leaf area per plant (cm^2), 3: Plant height (cm), 4: No. of primary branches per plant, 5: No. of secondary branches, 6: No. of nodes on main stem, 7: No .of internodes on main stem, 8: Days to 50% emergence, 9: Days to 50% flowering, 10: Days to first picking, 11: Single pod dry weight (g), 12: Single green pod weight (g), 13: Green pod length (cm),14: Green pod width (cm), 15: Green pod number per plant and 16: Green pod yield per plant (g), σ^2g: Genetic variability, σ^2p: Phenotypic variability, GCV: Genetic coefficient of variation, PCV: Phenotypic coefficient of variation, H: Heritability in the broad sense, GA: Genetic advance

Table 3: Adjusted mean values of 16 agronomic traits of 36 snap bean genotypes tested at Melkassa Agricultural Research Centers in 2010

		Traits															
No.	Genotypes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	S_{61}	21.30	82.5	20.5	37.9	3.3	1.4	8.8	7.8	8	42.5	52.0	3.96	0.45	14.06	8.70	940.5
2	HAB-408	27.45	95.8	18.2	43.3	3.7	1.2	9.3	8.3	9	42.0	52.0	3.55	0.55	13.02	8.09	770.5
3	PHA-5782/93	20.65	65.7	22.9	40.0	4.2	1.5	9.15	8.15	8	38.0	49.0	3.49	0.53	9.53	13.01	679.7
4	$BC_{4.4}$	11.95	32.2	24.8	34.9	4.2	1.7	10.95	9.95	8	47.0	55.0	3.13	0.35	12.59	8.22	598.6
5	HAB-419	29.6	79.7	27.4	31.0	4.3	1.7	8.3	7.3	8	41.0	52.0	2.87	0.42	11.71	8.54	909.3
6	Xera	31.1	98.1	23.9	34.5	4.9	1.5	9.5	8.5	7	43.5	51.0	3.45	0.39	11.87	7.46	427.5
7	L_{12}	21.0	80.7	23.6	33.9	3.9	1.5	9.1	8.1	10	44.0	52.0	3.66	0.35	13.84	7.95	676.3
8	Palati	26.2	133.6	22.2	33.9	4.3	1.4	8.1	7.1	8	43.5	53.0	4.98	0.40	12.69	7.95	933.6
9	HAB-448	26.55	98.3	30.1	62.2	4.4	1.9	11.35	10.35	8	43.5	53.0	3.5	0.44	12.62	7.27	802.2
10	PHA-24	31.8	81.6	26.9	51.7	4.3	1.4	8.5	7.5	8	43.5	58.5	2.6	0.37	10.75	8.88	814.5
11	HAB-430	37.7	143.6	19.9	34.5	4.2	1.4	8.7	7.7	8	39.5	51.0	3.86	0.43	13.78	8.40	798.9
12	PHA-5780/93	32.7	87.2	29.2	39.4	4.5	1.7	10.15	9.15	7.5	38.0	51.0	2.79	0.39	11.27	10.12	997.4
13	HAB-414	25.0	114.0	24.6	32.0	3.8	1.5	8.65	7.65	7	41.0	58.0	4.58	0.52	13.92	9.44	1302.4
14	Damater	22.5	75.0	21.7	33.9	4.5	1.3	9.1	8.1	9	42.5	55.0	3.2	0.35	11.54	7.84	662.1
15	PHA-6221/95	26.45	81.1	19.9	40.6	3.7	1.4	10.0	9.0	8.5	40.0	51.0	2.89	0.35	11.22	8.66	565.6
16	PHA-6048/95	24.45	62.4	21.9	36.4	4.5	1.5	8.15	7.15	9	42.0	53.0	2.57	0.33	13.07	7.47	770.2
17	HAB-436	26.6	114.7	18.7	34.2	4.4	1.4	8.65	7.65	8.5	40.0	51.0	4.59	0.50	13.94	8.99	745.9
18	PHA-404	28.85	99.7	22.6	34.8	4.2	1.5	8.85	7.85	9	42.0	51.0	3.59	0.58	12.52	9.11	1250.1
19	PHA-22	16.35	43.7	21.2	35.9	3.8	1.6	10.2	9.20	8	47.0	62.0	2.46	0.24	10.19	9.28	720.5
20	HAB-416	23.2	85.1	22.2	36.4	4.4	1.3	9.45	8.45	9	42.0	52.5	3.58	0.35	12.87	8.88	948.2
21	Odean	25.85	79.9	22.3	36.0	4.0	1.5	8.85	7.85	7.5	40.0	52.0	2.95	0.35	12.18	7.60	464.9
22	HAB -423	34.9	114.7	24.2	37.5	4.3	1.5	9.35	8.35	8	41.5	51.0	4.16	0.29	13.57	8.61	1054.6
23	HAB-431	26.55	78.9	22.5	41.4	4.3	1.4	9.40	8.40	8	39.5	51.0	3.04	0.42	11.80	8.12	785.6
24	Tema	38.75	113.3	21.9	42.3	4.1	1.6	11.7	10.70	8	39.5	51.0	2.99	0.48	14.05	7.65	810.9
25	S62	19.15	69.0	22.9	35.8	4.1	1.5	9.60	8.60	9	42.0	58.0	3.38	0.37	13.64	8.60	580.1
26	HAB-409	27.4	101.5	26.1	34.9	4.2	1.4	8.65	7.65	8	42.0	51.0	3.68	0.55	12.93	9.59	850.7
27	HAB-410	35.35	113.4	28.9	34.8	4.3	1.7	8.8	7.80	10	42.0	55.0	3.09	0.38	11.82	8.51	568.7
28	S6	20.15	72.5	28.6	37.3	4.3	1.9	12.1	11.10	8	42.0	54.5	3.64	0.35	12.79	8.02	761.2
29	Back	31.0	83.8	42.7	70.7	4.7	2.1	13.25	12.25	6.5	42.5	61.0	2.67	0.35	11.80	8.84	674.9
30	K3	18.35	61.9	21.4	78.0	4.1	1.4	10.5	9.50	7.5	45.0	58.0	3.42	0.45	13.78	7.46	699.9
31	A20	13.45	53.4	22.9	25.7	4.1	1.3	8.25	7.25	8	42.0	60.0	3.81	0.32	11.27	7.56	402.1
32	HAB-405	24.9	104.4	26.7	25.4	4.2	1.5	8.7	7.70	7.5	42.0	60.0	4.11	0.42	13.55	9.85	906.9
33	PHA-6039/95	27.0	85.9	19.2	37.4	4.3	1.5	9.35	8.35	7.5	39.0	51.0	3.07	0.38	13.91	8.87	508.7
34	PHA-5783/93	8.75	28.8	19.8	45.7	4.0	1.3	9.35	8.35	7.5	46.0	56.5	3.63	0.49	10.58	12.88	648.1
35	Polista	21.45	64.9	19.8	37.5	4.5	1.4	9.15	8.15	7.0	44.0	53.0	3.17	0.34	13.38	7.70	763.9
36	Containder	21.55	58.6	23.0	36.7	4.9	1.5	10.85	9.85	7.5	43.5	53.0	2.99	0.32	12.41	7.62	1073.1

1: Green pod number per plant, 2: Green pod yield (g) per plant 3: Leaf number per plant, 4: Plant height (cm), 5: No. of primary branches per plant, 6: No. of secondary branches, 7: No. of nodes on main stem, 8: Internode number on main tem, 9: Days to emergence, 10: Days to 50% flowering, 11: Days to first picking, 12: Single green pod weight (g), 13: Dry pod weight (g), 14: Green pod length (cm), 15: Green pod width (mm), 16: Leaf area per plant (cm^2)

width (16.35%), primary branches per plant (10.47%) and green pod length (10.72%) (Table 2). Similarly, medium PCV for single green pod weight and high PCV for pod number and green pod yield per plant was reported by Saha *et al.* (1990), Korla *et al.* (1998) and Singh *et al.* (2000), respectively.

Estimate of GCV was high for green pod yield per plant (24.96%) and plant height (26.43%). Medium GCV was observed for pod number per plant (19.55%), leaf area per plant (19.25%), single dry pod weight (16.11%), leaf number per plant (14.15%), single green pod weight (16.11%), node number on main stem (14.28%), internode number on main stem (15.89%) and green pod width (13.47%). In contrast, the rest traits showed low GCV (Table 2). Similar to the present finding, Saha *et al.* (1990), Korla *et al.* (1998) and Singh *et al.* (2000) reported medium GCV single green pod weight and number per plant, high GCV values for green pod yield per plant, respectively. Relatively high to medium estimates of GCV suggest effective selection (Rafiq *et al.*, 2010).

Broad sense heritability (Table 2) was high for plant height (88.1%), days to 50% flowering (68.5%), days to first picking (64.5%), green pod weight (61.3%), green pod length (60.1%) and green pod width (67.8%). Singh *et al.* (2000, 1991), Saha *et al.* (1990) and Sharma *et al.* (1977) also reported high heritability estimates for days to 50% flowering, green pod length, single green pod weight and pod width, respectively. Medium heritability was recorded for single dry pod weight (51.2%), leaf number per plant (35.7%), leaf area per plant (35.2%), pod number per plant (32.8%) and green pod yield per plant (45.8%). Similarly, Mishra and Dash (1991) and Korla *et al.* (1998) reported medium heritability for pod number per plant. The rest traits showed low heritability. Nimbalkar *et al.* (2002) reported low broad sense heritability for primary branches per plant.

As described in Poehlman and Sleper (1995) traits with high value of broad sense heritability could be used as an indicator of phenotype based selection especially if accompanied with relatively high variability and genetic advance values. In the present study, green pod yield (g) and pod number per plant showed high to medium heritability with corresponding high genetic advance indicating the prevalence of additive gene action governing these traits and could also be employed for phenotypic based selection for the improvement of these traits.

Genetic advance expected from 5% selection intensity expressed as percentage of the mean is presented in Table 2. Johnson *et al.* (1955) considered genetic advance as percent of the mean (GA%) to be low (0-10%), medium (10-20%) and high (>20%). Based on this classification, GA% was high for plant height (51.09%), green pod yield per plant (34.78%), green pod number per plant (23.08%), single green pod weight (24.31%) and green pod width (22.85). Medium genetic advance as percent of the mean was obtained for green pod length (13.29%). Similarly, high genetic advance was reported for green pod yield per plant, green pod number per plant, green pod weight and green pod width by Joshi and Mehra (1983), Singh *et al.* (2000), Singh *et al.* (1994) and Saha *et al.* (1990), respectively. The genetic advance as percent of the mean was low for days to emergence (8.32%), days to 50% flowering (7.98%), days to first picking (9.36%), primary branches per plant (2.39%) and secondary branches (7.38%). Similarly, Singh *et al.* (2000) and Pande *et al.* (1973) reported low genetic advance for days to 50% flowering and primary branches per plant, respectively.

Though days to 50% flowering and days to first picking recorded high heritability, the genetic advance as percent of the mean was low because of little genetic variation. Pod number and green pod yield per plant showed high to medium heritability and genetic advance as percent of mean as a result of adequate genetic variability. This indicated the prevalence of additive gene action governing these traits so that improvement through appropriate selection method is possible. Similar to the present finding, Das (2005) reported high genotypic coefficient of variation, heritablity and genetic advance for pod number and green pod yield per plant.

CONCLUSION

Generally, the present study entails the presence of genetic variability among the test genotypes with respect to the traits under investigation. Significant differences observed among most of the traits and large to medium genotypic and phenotypic coefficient variations indicated existence of considerable genetic variability among snap bean genotypes. Greater estimates of phenotypic coefficient variation than corresponding genotypic coefficient variation for all characters indicated the importance of environment in the expression of these traits. High to medium genotypic coefficient variation with high heritability and genetic advance for green pod yield, pod number per plant and single green pod weight indicated the possibility of improvement of these traits either through direct selection or hybridization.

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