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Full Length Research Paper

Genetic variation for grain yield and water absorption in common bean (*Phaseolus vulgaris* L.)

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Common bean (*Phaseolus vulgaris* L.) is commonly grown crop in Ethiopia. Increasing bean grain yield partly requires developing cultivars that are high yielding and high in water absorption. An experiment was carried out using 26 common bean genotypes grown during 2005 cropping season at Jimma, Ethiopia, to investigate genetic variances, broad-sense heritabilities and phenotypic correlation coefficients for grain yield and water absorption traits. Pods/plant, 100-seed weight (g), grain yield (g/plant) and water absorption showed high values of genetic variances. Genetic coefficients of variation ranged from 3.46(days to maturity) to 27.02 (water absorption). The broad sense heritability of grain yield, pods, seeds and water absorption were 72.36, 90.61, 58.50 and 87.09, respectively. The correlation between grain yield and pods/plant (r = 0.67; p = 0.01), and that of coat proportion and water absorption (r = 0.43; p = 0.05) were significant. This experiment suggests that selection for pods/plant could be used to improve grain yield per plant. Moreover, the presence of high broad-sense heritability values for water absorption suggests the existence of opportunity to improve this trait in common bean.

Key words: Broad-sense heritability, correlation, genetic variance, water absorption, grain yield, *Phaseolus vulgaris*.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is an important grain crop in Ethiopia occupying over 34% of the total crop area allocated to pulses and over 42% of the total pulses production (CSA, 2000). The development of high yielding common bean cultivars has been the major objective in common bean breeding programmes. However, adoption of a new cultivar would depend on its low cooking time and high water absorption capacity (Correa et al., 2010).

The estimation of genetic variance and heritability parameters for important traits is necessary in the selection of superior genotypes and to evaluate the breeding strategies (Falconer, 1989). Earlier studies in common bean showed considerable genetic variation for grain yield and yield components (Francis et al., 1978; Atuahene-Amankwa and Michaels, 1997; Dursun, 2007; Salehi et al., 2008), and water absorption (Santalla et al., 2001; Elia, 2003; Correa et al., 2010) indicating the possibility of improving grain yield and water absorption of this crop.

The major objectives of the present study were (1) to estimate the variance components and broad-sense heritabilities, and (2) to examine the phenotypic correlation coefficients for grain yield and water absorption parameters in common bean.

MATERIALS AND METHODS

This study was done by using 26 common bean genotypes obtained from Melkasa Agricultural Research Centre, Nazareth, Ethiopia. The experiment was conducted at Jimma, $7^{O}46´N,36^{O}E$, 1750m above sea level, during the main cropping season of 2005, at Eladale farm of Jimma University, College of Agriculture and Veterinary Medicine. The average annual rainfall and temperature for Jimma are 1574 mm and $19.65^{O}C$, respectively. Three seeds for each bean genotype were planted on July 14, 2005 and the seedlings were later thinned to one plant per hill two weeks after planting. The plots received 60 kg/ha N in the form of urea and diammonium phosphate (DAP) and equal amount of P_2O_5 (as DAP) at planting. Weeds were controlled with frequent hand weeding. The soil at 0-30 cm depth of experimental field is characterized by clay soil with pH 5.47 (in H_2O), organic matter 4.20%, total nitrogen 0.22%, and P 1.20 ppm.

The bean genotypes were planted in randomized complete block design with three replications. They were sown in four rows having

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Table 1. Level of significance, estimates of variance components and coefficient of variations for 26 common bean genotypes

Traits	Replication (df=2)	MSG (df=25	MSE (df=50)	δ^2_p	δ^2_e	δ^2_g	h^2	GCV	PCV	CV(%)
Days to flowering	0.63ns	23.75**	5.99	7.92	2.00	5.92	74.75	4.84	5.60	4.87
Days to maturity	16.65ns	43.79**	8.60	14.60	2.87	11.73	80.34	3.46	3.86	2.96
Pods/plant	22.37*	55.28**	5.20	18.43	1.73	16.70	90.61	24.75	26.00	13.81
Seeds/pod	0.15ns	1.21**	0.51	0.40	0.17	0.23	58.50	10.16	13.40	15.13
100-seed weight (g)	1.39ns	15.52**	0.87	5.17	0.29	4.88	94.39	12.93	13.31	5.46
Yield/plant (g)	48.05**	29.31**	8.09	9.77	2.70	7.07	72.36	20.66	24.29	22.10
Coat proportion	1.02na	5.06**	2.27	1.69	0.76	0.93	55.03	9.59	12.92	14.98
Water absorption	367.70ns	2293.20**	296.00	764.40	98.67	665.73	87.09	27.02	28.95	18.02

*, ** = significant at P = 0.05 and P= 0.01, respectively; ns = not significant; MSG = mean squares of genotypes; MSE = mean squares of error.

Table 2. Phenotypic correlation coefficients among eight traits in 26 common bean genotypes

	Traits	2	3	4	5	6	7	8
1	Day to flowering	0.44*	0.017	-0.07	-0.46*	-0.21ns	0.12ns	0.06ns
2	Days to maturity		0.41*	-0.39*	-0.41*	-0.09ns	-0.02ns	0.04ns
3	Pods/plant			-0.28ns	-0.40*	0.67**	0.12ns	0.2ns
4	Seeds/pod				-0.21ns	0.22ns	0.11ns	-0.07ns
5	100-seed weight (g)					-0.05ns	-0.13ns	-0.27ns
6	Yield/plant						0.24ns	0.05
7	Coat proportion							-0.43*
8	Water absorption							1

*, ** = significant at P = 0.05 and P= 0.01, respectively; ns = not significant.

row length of 3 m. Spacing between rows and between plants within row was 40 cm, and 10 cm, respectively. The pods/plant, seeds/pod, 100-seed weight (g) and grain yield (g/plant) were recorded on five random plants at each plot using central two rows. Proportion of seed coat (the ratio in weight between coat and cotyledon plus coat, after removing the coat from the cotyledon and drying them for 24 hrs at 105^0C), and water absorption (the amount of water dried seeds absorbed during soaking for 18 hrs) were measured according to Santalla et al.(2001).

STATISTICAL ANALYSES

Analysis of variance and estimation of phenotypic correlation coefficients were done using SAS statistical package (SAS Institute, 1996). Broad-sense heritability (h^2) was calculated as the ratio of the genotypic variance (δ^2_g) to the phenotypic variance (δ^2_p) as:

$h^2 = \delta^2_g / \delta^2_p$

where δ^2_g = (MSG-MSE)/r), MSG and MSE = mean squares of genotypes and error, respectively, and r are the number of replications. The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were computed according to Burton (1952) as:

$GCV = (\delta^2_g)^{0.5}/z) \times 100$

$PCV = (\delta^2_p)^{0.5}/z) \times 100$

where z is the general mean of a trait.

RESULTS

The values of δ^2_g were 7.07 for grain yield/plant, pods/plant 16.70, seeds/pod 0.23, water absorption 665.73, coat proportion 0.93, and 100-seed weight 4.88. The highest genotypic and phenotypic coefficients of variation (> 20%) were observed for pods/plant, grain yield/plant, and water absorption. Broad-sense heritability estimates were ranged from 55.03 (coat proportion) to 94.39(100-seed weight) and the broad-sense heritability values for grain yield/plant, pods/plant and water absorption were also high (Table 1).

The correlation between grain yield and pods/plant (r= 0.67, p=0.01) and that of coat proportion and water absorption(r= 0.43; p=0.05) were significant. The 100-seed weight however did not show significant correlation with seeds/pod and grain yield as well as water absorption (Table 2).

Grain yield ranged from 8.47g/plant (XAN-316) to 23.70 g/plant (AWASH-1). Pods/plant ranged from 10.73 to 30.50, seeds/pod 3.09 to 5.88 and water absorption from 30.84 to 128.00(Table 3).

DISCUSSION

The coefficients of genotypic and phenotypic variations were generally low for days to flowering and maturity which could be due to limited variability in the genetic materials studied. As in present experiment, the existence of considerable genetic variations in common bean was also reported for grain yield, pods/plant,

Table 3. Mean values for eight traits for 26 common bean genotypes

Genotypes	Days to flowering	Days to maturity	Pods/plant	Seeds/pod	100-seed weight (g)	Yield/plant (g)	Coat proportion	Water absorption
AFR-685	50.00	95.33	12.13	5.38	18.21	15.53	10.90	108.80
FEB 183	48.67	96.00	13.50	5.33	16.17	12.50	9.08	128.00
FEB 182	45.67	98.33	13.93	4.72	17.93	13.00	10.86	99.06
MAM-48	45.00	92.00	16.20	3.84	24.76	15.68	8.64	103.81
NZBR-6	48.33	90.67	13.67	5.54	17.59	13.45	10.81	37.95
DOR-732	50.00	100.00	15.53	4.98	18.71	14.21	10.95	30.84
XAN-310	54.00	101.00	14.30	4.16	17.38	9.13	13.58	43.95
DICTA-109	50.00	97.00	13.67	4.50	18.25	10.88	10.91	64.85
DOR-811	49.33	100.30	16.40	5.00	18.80	16.02	10.10	76.31
XAN-307	54.00	99.33	12.80	4.81	16.90	10.74	10.70	122.81
EMP-388	50.00	96.00	10.73	5.88	16.25	8.53	9.93	114.27
XAN-316	47.33	95.00	12.33	4.09	19.29	8.47	10.49	106.31
DOR-564	51.33	102.70	15.93	4.93	16.37	12.63	10.61	54.20
RED-WOLAITA	49.33	99.00	12.40	5.01	20.11	12.17	7.77	84.14
EMP-311	54.00	102.00	17.87	4.68	16.37	13.79	10.49	111.36
STTT-165-91	54.00	105.30	23.10	4.02	15.41	14.25	9.42	105.02
STTT-165-96	52.67	103.00	22.13	3.09	16.49	11.93	9.30	126.23
AFR-720	51.33	100.70	21.70	5.11	16.11	15.27	10.62	113.60
PAN-182	50.00	96.00	16.07	4.58	16.59	10.28	7.45	116.52
UTT-28-173	46.67	108.00	18.60	4.04	16.84	10.27	9.01	95.49
EMP-290	54.00	102.00	16.00	4.04	15.93	11.75	9.91	91.58
UTT-27-4	48.67	101.00	17.70	4.16	15.44	10.06	9.17	99.79
NZBR-2-5	54.00	99.67	19.80	5.07	12.58	15.27	9.93	119.67
AWASH-1	46.00	98.00	30.50	5.07	15.12	23.70	12.42	107.02
EMP-314	52.67	100.30	14.57	5.39	16.95	12.06	8.94	114.24
MEX-142	49.33	98.33	17.73	5.18	13.63	13.12	9.58	106.87
Mean	50.24	99.11	16.51	4.72	17.08	12.87	10.06	95.49
LSD(0.05)	4.02	4.81	3.74	1.17	1.53	4.67	2.47	28.24

seeds/pod (Atuahene-Amankwa and Michaels, 1997; Salehi et al., 2008), 100-seed weight (Atuahene-Amankwa and Michaels, 1997; Dursun, 2007), and coat proportion and water absorption (Santalla et al., 2001). This variation in water absorption could be used to predict cooking times in beans, as Elia (2003) showed that slow cooking beans imbibe less water than fast cooking ones.

In the present experiment coat proportion and water absorption showed low to moderate broad-sense heritability values. The broad-sense heritability values for these traits were also reported to range from low (Santalla et al., 2001) to moderate (Escribano et al., 1997). The moderate to high broad-sense heritability values observed in this experiment for grain yield, pods/plant and 100-seed weight agree to the reports of Santalla et al. (2001), despite that Dursun (2007) reported low broad-sense heritability values for these traits.

In the present experiment, the positive correlation between pods/plant and grain yield indicates that the former trait would be used to improve grain yield. This trait was also suggested to be useful character to select for high yield in common bean breeding programs (Atuahene-Amankwa and Michaels, 1997; Dursun, 2007; Salehi et al., 2008). In this experiment, absence of significant correlation between grain yield and seed weight, and negative correlation between coat proportion and water absorption agrees with reports of Atuahene-Amankwa and Michaels (1997), and Santalla et al. (2001), respectively. Moreover, the presence of high broad-sense heritability for water absorption suggests the existence of opportunity to improve this trait in common bean.

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