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Genetic study and selection of soybean lines for higher yield

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Abstract

Soybean (*Glycine max* L. Merrill) is a foremost source of oil and protein worldwide. The demand of soybean has increased tremendously in Bangladesh though the yield cannot keep pace with the growing demand due to differences in varietal performance. Therefore, the present study has been undertaken to assess the morphological features and yield attributes of different soybean genotypes which may help in estimating the heritability and genetic advances of yield and yield components among different soybean genotypes. A field experiment was conducted during Rabi season with 10 soybean genotypes using randomized complete block design with three replications. Nevertheless, all of the studied characters revealed significant divergence among different soybean genotypes. The genotypes BARI Soybean-5, BAU-S/147, AV-14, Sohag, BAU-S/109 and AV-78 produced high yield per plant. The genotype BAU-S/70 was the tallest one and AV-14, AV-73 and Sohag were early maturing genotypes. High genotypic and phenotypic variance were observed for flowers per plant, pods per plant, plant height and days to maturity whereas low genotypic and phenotypic variance were recorded for harvest index, seeds per pod, 100 seed weight and branches per plant. High heritability values accompanied with high genotypic coefficient of variation and high genetic advance as percentage of mean were also observed for harvest index, yield per plot, yield per plant, seeds per pod, pods per plant, flowers per plant, plant height and branches per plant. The findings of the study will play a pivotal role in selection of superior soybean genotypes in terms of yield and yield components for further genetic improvement.

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Introduction

In terms of total production and international trade, Soybean *(Glycine max* L. Merrill) is the world's most important oil producing grain legume crop. The golden bean, soybean belongs to the family Leguminosae, sub-family Papilionaceae, is one of the most important economical food legumes cultivated world-wide because of its higher nutritional and industrial values. For its nutritive value, soybean has been called as miracle golden bean. The crop is grown throughout the world which accounts for approximately 50% of the total production of oil seed crops in the world (FAO, 2007). The largest soybean producing countries are: The USA, Brazil, Argentina, Mexico, China and Indonesia (FAO, 2007). The acreage of soybean in Bangladesh is around 22,000 acres and production was 6,000 metric tons in the year of 2006-07 (BBS, 2008). With the growth of population, Bangladesh needs more protein, fat and minerals for meeting the nutritional demand for this increased population. Unfortunately, our protein sources are limited. Soybean can play a significant role in providing support to this increased protein demand. Soybean can be grown, as a source of protein and of oil crops as well as has become a cash crop in our country. Considering these facts, the present study was conducted with 10 soybean genotypes to observe the nature of relationship of different morphological characters and yield attributes among themselves and to estimate heritability and genetic advance of yield and yield components.

Materials and methods

Land Preparation

The experiment was conducted at the experimental field of Department of Genetics and Plant Breeding, Bangladesh Agricultural University (BAU), Mymensingh. Ten soybean genotypes (Table 1) were grown in randomized complete block design (RCBD) with three replications during Rabi season 2011. Plot size was 4 m × 2.5 m. Block to block 1 m, plot to plot 60 cm, line to line 30 cm and plant to plant 5 cm distances were maintained.

Fertilization

For fertilization, Urea, TSP (triple super phosphate), MOP (muriate of potash) were applied @ 60-150-70 kg/ha respectively. The land was uniformly fertilized with TSP, MOP and well-rotted cow dung at the time of final land preparation. One third of urea was applied during the final land preparation and the rest two third of urea was applied in two equal splits as top dressing, one at the vegetative phase (40 DAS-days after sowing) and the other at flowering stage (65 DAS). Seeds were inoculated with *Bradyrhizobial* inoculums @ 25 g/kg seed before sowing which is recommended for soybean cultivation by BARI Hand Book.

Sowing, harvesting and data recording

Seeds were sown in continuous rows keeping the row to row distance of 30 cm. Normal intercultural practices and plant protection measures were followed to raise the crop successfully. Crop was successfully harvested. Total plot was harvested for measuring grain yield. Data were collected from 10 randomly selected plant of each unit plot. Data were recorded on days to flowering, days to maturity, plant height, branches per plant, pods per plant, seeds per pod, 100 seed weight, flowers per plant, pod setting efficiency, yield per plant, yield per plot and harvest index**.**

Data analysis

All data obtained from each trait were statistically analysed using MSTAT-C software package and Microsoft Office Excel 2007. The analysis of variance was done according to Goulden's methods (1959). Genotypic coefficient of variation was computed using the formula suggested by Burton (1953). Heritability in broad sense and genetic advance was calculated according to the methods given by Jonsson (1955) and Hanson *et al.* (1956).

Results and discussion

Analysis of variance

Analysis of variance (Table 2) for the characters showed that there were significant variations among the genotypes for days to flowering, days to maturity, plant height, branches plant, pods per plant, seeds

per pod, 100 seed weight, flowers per plant harvest index, yield per plant, pod setting efficiency and yield per plot. These indicates that there was genetic variation among the genotypes for the characters studied. The range of variation in all the genotypes for all of the traits was high.

Performance of the genotypes

The performance of the genotypes for yield and its different morphological yield contributing characters were evaluated in the field (Table 3). The genotypes differed significantly for all of the characters indicating existence of variation at genetic level.

Days to first flowering

Among all the genotypes, AV-62 took longest days (47 days) for flowering. This was closely followed by that of BAU-S/70 (46.33 days) and BARI Soybean-5 (45.33 days) (Table 3). Nonetheless, AV-41 took fewer days (35 days) to flowering.

Days to maturity

The genotype AV-62 was the last for the number of days (121.00 days) to maturity followed by AV-78 (119.00 days) and BAU-S/109 (115.00 days) and shortest days (94.00 days) to maturity genotype was AV-14 followed by AV-73 (101.00 days) and BAU-S/80 (109.00 days) (Table 3).

Plant height (cm)

Significant variations were observed for plant height among all genotypes (Table 3). The genotype BAU-S/70 was the tallest (69.57 cm) followed by AV-62 (61.77 cm) and Sohag (53.67 cm). AV-78 was the shortest genotype (33.20 cm) in height followed by AV-14 (39.40 cm) and BAU-S/109 (39.47 cm) and these genotypes were dwarf and erect.

Table 1. List of ten soybean genotypes used in the study.

Serial no.	Genotypes	Seed Source
1.	AVRDC-14 (Sl-4)	Plant Breeding Division, BINA, Mymensingh
2.	AVRDC-62 (Sl-14)	Plant Breeding Division, BINA, Mymensingh
3.	AVRDC-73 (Sl-11)	Plant Breeding Division, BINA, Mymensingh
4.	Sohag	Plant Breeding Division, BINA, Mymensingh
5.	AVRDC-78 (Sl-01)	Plant Breeding Division, BINA, Mymensingh
6.	BAU-S/70	Plant Breeding Division, BINA, Mymensingh
7.	BAU-S/80	Plant Breeding Division, BINA, Mymensingh
8.	BARI Soybean-5	Plant Breeding Division, BINA, Mymensingh
9.	BAU-S/109	Plant Breeding Division, BINA, Mymensingh
10.	BAU-S/147	Plant Breeding Division, BINA, Mymensingh

Branches per plant

Branches per plant showed significant variation among genotypes. AV-62 produced highest (5.27) number of branches per plant (Table 3). This was followed by BAU-S/109 (4.27) and Sohag (4.13), which had comparatively higher number of branches than others. AV-78 (2.97) showed statistically identical values in respect of branches per plant. Other genotypes producing lower number of branches were AV-14 (3.40), BAU-S/70 (3.57) and AV-73 (3.67). These results indicate that genotypes higher number of branches per plant exhibited by the genotypes could be used for selection and could result in better performing varieties.

Pods per plant

The highest number of pods per plant (60.93) was recorded in BAU-S/80, BAU-S/147 (56.67) and AV-62 (54.60) while the lowest number of pods per plant (21.53) observed in AV-78 followed by the AV-14 genotype (25.27) (Table 3).

Seeds per pod

Among all the genotypes, BAU-S/109 produced the

highest amount of seeds (2.37) (Table 3). BAU-S/147 (1.85), Sohag (1.86), BAU-S/80 (1.86) held in the second position in respect of seeds per pod. The lowest amount of seeds (1.74) was produced in AV-73 genotype.

100 seed weight (g)

Seed weight is one of the most important yield contributing character components of yields contribution (Table 3). The highest value of 100 seed weight (12.19 g) was recorded from BAU-S/147 genotype. Genotypes BAU-S/70 (11.90 g), BAU-S/80 and BAU-S/109 (11.47 g) and BARI Soybean-5 (11.31 g) also showed higher hundred seed weight. Lower values of seed weight were found in AV-14 (11.36) and AV-78 (11.07 g) genotypes. However, lowest seed weight (10.41) was recorded in case of AV-62 genotype.

Table 2. Analysis of variance (mean square.

Characters	Sources of variation		
	Replication(df=2)	Genotype(df=9)	Error(df=18)
Days to flowering	5.23	54.21**	1.42
Days to maturity	2.23	196.70**	1.01
Plant height(cm)	2.004	371.69**	1.49
Branches per plant	0.11	1.13**	0.16
Pods per plant	9.84	618.18**	9.06
Seeds per pod	0.03	0.11**	0.02
100 seed weight (g)	0.22	0.92*	0.38
Yield per plot (kg)	0.05	2.52**	0.08
Flowers per plant	54.51	678.55**	115.04
Harvest index	0.0004	0.007**	0.0004
Pod setting Efficiency	0.39	29.44**	1.73
Yield per plant	0.26	0.20**	13.66

values) for various important characters of 10 soybean genotypes.

df = Degrees of freedom, * and ** = Significant at 5% and 1% level respectively.

Yield per plot (kg)

Plot yield showed significant variation among genotypes. BAU-S/109 produced highest (3.68 kg) grain yield per plot followed by BAU-S/80 (3.59 kg) and BAU-S/147 (3.57 kg) produced second higher grain yield per plot (Table 3). AV-78 (1.21 kg), AV-73 (1.40 kg) and AV-14 (1.82 kg) produced the lowest amount of grain yield per plot.

Flowers per plant

The highest flowers per plant (59.00) were observed from BAU-S/80, AV-62 (58.33) and BAU-S/147 (55.13) Genotypes (Table 3). However, it was AV-78 that produced lowest number (19.87) of flowers per plant. Later on, AV-73 and AV-14 produced the second (22.03) and third (28.20) lowest number of flowers per plant, respectively.

Harvest index

For harvest index, the genotypes BAU-S/109, BAU-S/80, BAU-S/147, BARI Soybean-5, BAU-S/70 and Sohag produced highest harvest index (above 30%) (Table 3). On the other hand, AV-62 showed the lowest harvest index (0.25). From above results, the genotypes BARI Soybean-5, BAU-S/109, BAU-S/80 appeared as the most promising ones. Pods per plant, seeds per pod, harvest index and finally grain yield per plant were higher for those genotypes.

Pod setting efficiency

The highest pod setting efficiency was found in BAU-S/80 (97.22) followed by BAU-S/147 (97.10), BAU-S/70 (96.46) and Sohag (94.39) genotypes. On the other hand, genotype AV-78 produced the lowest number (87.56) of pods (Table 3).

Table 3. Mean performance of 10 soybean genotypes in respect of different characters studied.

Genotypes	Days to first flowering	Days to maturity	Plant height (cm)	Branches per plant	Pods per plant	Seed per pod
AV-14	35.00 g	94.00 g	39.40 e	3.40 cd	25.17 e	1.76 b
AV-62	47.00 a	121.00 a	61.77 b	5.27 a	54.60 b	1.76 b
AV-73	35.33 g	101.0 f	39.77 e	3.67 bcd	22.80 e	1.74 b
Sohag	42.00 e	110.70 e	53.67 c	4.13 bc	40.00 d	1.86 b
AV-78	41.67 e	119.00 b	34.33 f	2.97 d	21.53 e	1.78 b
BAU-S/70	46.33 b	113.00 d	69.57 a	3.57 bcd	45.20 c	1.80 b
BAU-S/80	43.67 d	109.00 e	52.63 c	3.80 bc	60.93 a	1.86 b
BARI Soybean-5	45.33 c	114.00 cd	49.10 d	3.97 bc	46.53 c	1.76 b
BAU-S/109	41.00 f	115.00 c	39.47 e	4.27 b	46.07 c	2.37 a
BAU-S/147	45.33 c	113.00 d	52.33 c	4.07 bc	56.67ab	1.85 b
LSD at 5%	2.04	1.72	2.09	0.68	5.16	0.21
CV%	2.82	0.91	2.48	10.11	7.18	6.52

Table 3 (continued)

Genotypes	100 seed weight (g)	Pod Yield (g)	Flowers/plant	Harvest index	Pod Setting efficiency	Yield/Plant (g)
AV-14	11.36 ab	1.82 c	28.20 bc	0.28 de	91.23 d	5.07 c
AV-62	10.41 b	3.29 a	58.33 a	0.25 e	91.64 d	2.43 e
AV-73	10.48 b	1.40 cd	22.03 c	0.27 de	91.31 d	6.93 b
Sohag	11.45 ab	2.53 b	44.00 ab	0.32 bc	94.39 bc	4.70 c
AV-78	11.07 ab	1.21 d	19.87 c	0.26 de	87.56 e	4.50 c
BAU-S/70	11.90 a	2.74 b	44.07 ab	0.32 bc	96.46 ab	3.33 d
BAU-S/80	11.47 ab	3.59 a	59.00 a	0.37 a	97.22 a	2.30 e
BARI Soybean-5	11.31 ab	2.68 b	52.93 a	0.30 cd	93.23 cd	8.83 a
BAU-S/109	11.47 ab	3.68 a	31.87 bc	0.38 a	95.31 abc	4.51 c
BAU-S/147	12.19 a	3.57 a	55.13 a	0.35 ab	97.10 a	7.31 b
LSD at 5%	1.05	0.47	18.40	0.04	2.26	0.77
CV%	5.41	10.32	25.82	6.75	1.41	9.01

Yield per plant (g)

Yield is the final product of crop, which relies on other contributing characters. So, finally to evaluate a crop, it is essential to rank its yield potentialities (Table 3). Considering grain yield per plant, it ranged from 2.30 g to 8.83 g. Among all the genotypes studied, BARI Soybean-5 produced the highest yield per plant (8.83 g). Next two genotypes were BAU-S/147 (7.31 g) and AV-14 (5.07 g). They were statistically identical, but BAU-S/80 showed the lowest grain yield per plant (2.30 g), which was statistically similar to that of AV-62 (2.43 g) and BAU-S/70 (3.33 g) genotypes.

Variability, heritability and genetic advance

Genotypic and phenotypic variance, heritability and genetic advance for yield and different yield contributing characters in soybean were presented in Table 4, Table 5 and Table 6. It was found that there were significant variations among the genotypes for all characters studied. Gawandi *et al.* (2002) estimated significant variability among genotypes for days to maturity, plant height and number of branches per plant, number of pods per plant and seed yield. Mallarino *et al.* (2001) recorded highly significant variations among yield, 100 seed weight, days to maturity, plant height, number of branches per plant and number of pods per plant.

High genotypic and phenotypic variance was

observed in flowers per plant, pods per plant, plant height, days to flowering, days to maturity and pod setting efficiency. Low magnitude of genotypic and phenotypic variance was found in harvest index, seeds per pod, 100 seed weight, branches per plant, yield per plot and yield per plant. The highest genotypic coefficient of variations (GCV) was found in flowers per plant. This was followed by pods per plant, plant height, days to maturity, days to flowering and pod setting efficiency. This high genotypic coefficient of variation of those traits indicated the scope for effective selection. In contrast, low genotypic coefficient of variation for seeds per pod, harvest index, 100 seed weight, branches per plant, yield per plant and yield per plot indicated low genetic variability and limited scope for improvement.

Table 4. Range, mean, CV (%), and SE (±) for different characters of 10 soybean genotypes.

Characters	Range for individual character		Grand mean	Coefficient of variability (% CV)	SE (±)
	Minimum	Maximum			
Days to flowering	34.00	48.00	42.27	2.82	0.776
Days to maturity	93.00	122.00	110.97	0.91	1.436
Plant height(cm)	33.20	70.40	49.20	2.48	1.969
Branches per plant	2.80	5.40	3.91	10.11	0.123
Pods per plant	19.60	63.80	41.95	7.18	2.570
Seeds per pod	1.60	2.63	1.86	6.52	0.038
100 seed weight (gm)	10.07	12.85	11.31	5.41	0.133
Yield per plot (kg)	1.15	4.08	2.65	10.32	0.166
Flowers per plant	19.40	72.00	41.54	25.82	3.086
Harvest index	0.24	0.39	0.31	6.75	0.009
Pod setting efficiency	86.73	98.50	93.55	1.41	0.584
Yield per plant (g)	2.00	9.20	4.99	9.01	0.382

Study of GCV indicated that flowers per plant exhibited highest genotypic coefficient of variation whereas lowest for harvest index. Agarwal *et al.* (2001) recorded high GCV for flowers per plant and branches per plant. Estimated GCV were low for harvest index.

The differences between GCV and PCV (Phenotypic coefficient of variation) were very low for all of the characters studied which showed that the environmental effects in the development of these characters were minimum. Salimi *et al.* (2013) found that the value of phenotypic coefficient of variation were higher than that of genotypic coefficient of variation. The estimated value of GCV and PCV were highest for flowers per plant and pods per plant among the characters. Furthermore, it was found that very low difference for harvest index, seeds per pod and branches per plant indicated the low environmental influences on the expression of those characters. Srinives *et al.* (2001) had also observed low environmental effect in influencing these characters in soybean.

The study of heritability indicated that the characters of flowers per plant, pods per plant, plant height, days to maturity, days to flowering, pod setting efficiency, yield per plant, yield per plot, branches per plant, 100 seed weight, seeds per pod and harvest index were highly heritable.

Chamundeswari and Aher (2003) observed highest broad sense heritability for plant height and number of pods per plant. According to Khan *et al.* (2000) heritability ranged from 29.37 % for seeds per pod to 98.98 % for days to maturity. Characters having high heritability can be used as selection criteria for breeding program.

Praneetha and Thamburaj (1997) observed high

heritability for pods per plant, yield per plant and branches per plant. Nehru *et al.* (1999) and Jungle *et al.* (1994) recorded high heritability for days to maturity. High heritability together with high genetic advance was observed for pods per plant and plant height. Mehetre *et al.* (1997) reported high heritability values accompanied with high genetic advance for plant height and pods per plant.

Table 5. Phenotypic, genotypic and environmental variances for different characters of 10 soybean genotypes.

Characters	Phenotypic variance (Vp)	Genotypic variance (Vg)	Environmental variance (Ve)
Days to flowering	54.207	53.734	0.473
Days to maturity	196.70	196.36	0.337
Plant height(cm)	371.69	371.19	0.497
Branches per plant	1.128	1.076	0.052
Pods per plant	618.17	615.157	3.020
Seeds per pod	0.106	0.101	0.005
100 seed weight (g)	0.915	0.790	0.125
Yield per plot (kg)	2.517	2.492	0.025
Flowers per plant	678.55	640.208	38.346
Harvest index	0.0065	0.0064	0.0001
Pod setting Efficiency	29.444	28.867	0.577
Yield per plant (g)	13.664	13.597	0.067

Thus above results suggest substantial contributions of additive genes for expression of these traits. Therefore, direct selection of these traits would be highly effective. Characters like yield per plant and branches per plant showed moderate heritability with low genetic advance. Bhandarkar (1999) observed moderate heritability for yield per plant. Similarly, pods per plant and seeds per pod showed low heritability and low genetic advance. This suggest that the role of non-additive gene action for control of those characters. Heritability was higher than 60 % for all parameters (except seeds per pod) showed heritable variance among genotypes. Genetic advance (GA) as percentage of mean for yield per plant, plant height and pods per plant was higher showed that these parameters were under the control of additive genes. This is in confirmation with the results as stated by Khan *et al.* (2000).

Table 6. Estimates of genetic parameters of different characters of 10 soybean genotypes.

Traits/ Genetic Parameters	Heritability (%)	PCV	GCV	GA (%)	GAMP
Days to flowering	99.127	17.418	17.342	35.568	84.14478
Days to maturity	99.829	14.87	12.628	25.991	23.42165
Plant height (cm)	99.866	15.18	39.159	80.615	163.8516
Branches per plant	95.390	7.43	26.260	53.376	1365.115
Pods per plant	99.511	32.87	59.124	121.498	289.6257
Seeds per pod	95.283	11.98	17.086	34.357	1847.151
100 seed weight (g)	86.339	14.64	7.859	15.043	133.0062
Yield per plot (kg)	99.007	15.78	59.570	122.103	4607.66
Flowers per plant	94.349	43.45	60.911	121.878	293.3991
Harvest index	98.462	13.28	25.806	52.750	17016.13
Pod setting efficiency	98.040	5.62	5.743	11.750	12.56013
Yield per plant (g)	99.510	2.12	73.896	151.852	3043.126

PCV = Phenotypic coefficient of variation, GCV = Genotypic coefficient of variation, GA = Genetic advance as percent and GAMP = Genetic advance as percent of mean.

High heritability coupled with high genetic advance for yield per plant was found in the present study. It is suggesting that most likely the high heritability is due to additive gene effects and selection may be effective. Similar results of high heritability and genetic advance as percentage of mean for all the plant growth characters except for days to maturity were reported by Agarwal *et al.* (2001).

In the present study, high heritability and genetic advance as percent of mean for plant height, branches per plant, seeds per pod, 100 seed weight, pods per plant and harvest index indicated the possibility of improvement of these traits contributing to yield.

These results can be collaborated by results of Jagdish *et al.* (2000) who showed high heritability for pods per plant and plant height with high genetic advance as percentage of mean. Again, Jain and Ramgiry (2000) observed high heritability estimates accompanied by high genetic advance as percentage of mean for seed yield, plant height and pods per plant. These traits were found major yield contributing traits in soybean.

Conclusion

Among the characters studied for heritability, it was observed that the characters like plant height, days to maturity, pods per plant, yield per plant, days to flowering and plot yield were highly heritable. A high heritability associated high genetic advance as percentage of mean was observed for yield per plant, yield per plot flowers per plant, pods per plant, plant height and harvest index. High heritability accompanied by high genotypic coefficient of variation and high genetic advance were observed for plant height, pods per plant, 100 seed weight, days to maturity and yield per plant. Therefore, it is suggested that plant height, pods per plant, 100 seed weight, days to maturity could be used as important selection criteria for yield improvement of soybean.

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