



Genetic Variability, Heritability, and Correlation of Some Agronomical Characters of Soybean Varieties

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Abstract

Genetic diversity and inheritance of the traits determine the success of the breeding program. Analysis of genetic variability and heritability assist breeders to decide a strategy and appropriate selection criteria that will be used to repair the desired character. The purpose of this study was to obtain information about genetic diversity, heritability and correlation of nine agronomic characters of soybean varieties. The materials were 16 soybean varieties that arranged in a randomized block design with three replications. The results showed that days to flowering, number of branches per plant, number of reproductive nodes, number of unfilled pods per plant, weight of 100 seeds, and grain yield revealed broad GCV (Genetic Coefficient of Variance), whereas the days to maturity, plant height, number of pods per plant had a narrow GCV. PCV (Phenotypic Coefficient of Variance) value higher than the value of GCV on all the observed characters with a slight difference, except for grain yield. The broad sense heritability varied from low (seed yield), medium (the number of branches, number of reproductive nodes, number of pods and the number of unfilled pods), and high (days to flowering, days to maturity, plant height, and weight of 100 seeds). Characters of days to flowering and weight of 100 seeds are effectively used as selection criteria because they had a broad GCV and high heritability. Correlation of all yield components to the seed yield was not significant, and negatively correlated to weight of 100 seeds. Variety with higher plant height tended to have a higher number of branches, reproductive nodes and filled pod per plant.

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INTRODUCTION

Improvement of agronomic traits to increase soybean productivity can be done through breeding programs. In developing new high yielding varieties, genetic resources play a crucial role (Priadi *et al.*, 2016). One of the components that determine the success of the breeding program is the availability of wide genetic variability, both derived from germplasm collection and wild species. The broad genetic variability allows selection on more genetic materials to obtain a genotype with desired character. Selection can only be done effectively on the characters that can be inherited and only works on existing characters, which means that the selection cannot create variability (Allard, 1988).

The development of soybean varieties in Indonesia, in addition to producing high-yielding varieties of soybean productivity, is also directed to a specific adaptive agroecology. Thus, the soybean varieties obtained can provide high economical benefits. The relationship between the characters of plants needs to be studied in the process of developing a new soybean variety. The variety development to improve the quality of a character is much simpler than some characters at once. So that the time required to produce a new varieties with some different characters is also longer. Agronomical characters can be divided into qualitative and quantitative characters. The qualitative character has phenotypic easily distinguishable, such as the color of flowers, pod, hilum, and seed coat. Contrary, the quantitative characters are difficult to be distinguished due to the observation problems, such as yield and yield components. Grain yield character, controlled by several genes, can be influenced by the physicochemical and the environmental properties making it as a more complex character. Characters of yield and yield components are also influenced by other components (Dilnesaw *et al.*, 2013). Mahbub *et al.* (2015) reported that the plant height, number of pods per plant and the number of seeds per plant are influenced by the environmental factors, while the other yield components characters are more influenced by genetic factors.

Improvement of a character will alter the other related characters. The positive correlation between characters alters the related characters in the same direction, while the negative correlation changes in the opposite direction. Mahbub *et al.* (2015) reported a positive correlation between the number of pods, plant height, number of branches, the number of seeds per pod, number of seeds per plant. Seed yield per plant showed sig-

nificant and positive correlation on yield, number of pods per plant and weight of 100 seeds. This indicates that the selection of these characters will be more effective than other yield components (Jain *et al.*, 2015).

In the new varieties development program, some parameters such as genetic coefficient of variability (GCV), the phenotypic coefficient of variability (PCV), heritability and genetic advance are often used to determine the effectiveness of a selection method (Akram *et al.*, 2011; Baraskar *et al.*, 2014; Aditya *et al.*, 2011; Dilnesaw *et al.*, 2013; Ghodrati, 2013). The high value of GCV and PCV indicate the effective selection. Similarly, heritability also has high role in a selection (Kuswanto, 2017b). Heritability is more accurate if it is equipped with genetic advance to determine the selection value. The high heritability followed by genetic advance on grain yield per plant, number of branches per plant, number of pods per plant, plant height and seeds yield per plant indicates the additive genes role, therefore, the selection of these characters will be effective on the earlier generation (Akram *et al.*, 2011). High heritability values indicate that the character is influenced by genetic factors rather than environmental factors. It is also reported by Ghodrati (2013) for plant height and number of reproductive nodes. Therefore, it is important to study the influence of each yield components on yield, and to selecting the genotypes that have a high seed yield by viewing the relationship between yield and seed yield components. Correlation study is capable of measuring the relationship between the characters and can assist in identifying the desired characters as the basis for selection.

METHODS

Experiment site

The study was carried out in Jambegede Research Station of Indonesian Legume and Tuber Crops Research Institute (Iletri) from August to November 2016. The coordinate of experiment site was -8.174951 (South) and 112.559634 (East), with the altitude of 308 m above sea level. The soil type in this experiment site was associated Entisols-Inceptisols.

Soil preparation

Before soil tillage, the land was cleared from the weed and the other residues of previous plants. Soil tillage was carried out by using tractor until the soil became crumbly. A rake was used to leveling the soil. Drainage canals were made with 20 cm depth and 40 cm width every

3 m.

Plant materials and planting

The plant materials were 16 soybean varieties from Ietri's collection including Detam 2, Grobogan, Seulawah, Merbabu, Tanggamus, Sibayak, Kaba, Galunggung, Detam 1, Gunitir, Cikuray, Gepak Kuning, Dering 1, Argomulyo, Malabar, and Panderman. Planting date was August 1st, 2016. Every variety was grown in two rows of 3 m length. Before planting, the seed was treated using insecticides of Carbosulfan. Planting was done by using 15 cm × 40 cm planting space with 3-4 seeds per hill. At 14 days after planting (DAP), the seedlings were thinned becoming two plants per hill.

Cultural practice

Fertilizer with the doses of 75 kg ZA, 100 kg SP36, 75 kg KCl, and 1 ton organic manure per ha were applied at the sowing time. To prevent excessive weed growth, weeding was done manually at 2 and 4 weeks after planting (WAP). Pests and diseases were controlled by monitoring the population and pesticides were applied.

Data analysis

Data were analyzed by analysis of variance using PKBT program (Pusat Kajian Buah Tropika; Institut Pertanian Bogor (PKBT-IPB). Genetic parameter analysis was performed according to Jain *et al.* (2015). The deviation of genetic variance was used to determine the criteria of genetic variability.

RESULTS AND DISCUSSION

Plant breeding program will succeed if the genetic variability of the desired character is

available. Based on the mean square value, all observed characters showed significant differences among the genotypes except seed yield character (Table 1). This may imply that the days to flowering, days to maturity, plant height, number of branches, number of reproductive nodes, number of filled pods and unfilled pods per plant and weight of 100 seeds had a wide variability among genotypes.

The average and range of values of the observed characters are presented in Table 2. Days to flowering ranged from 32 to 40 days with an average of 36.41 days. Days to maturity of the tested varieties ranged moderate to very long age according to Indonesian soybean classification (82.33 to 100 days). The same genotypes express longer growth duration in sub-tropical than in tropical climate (Kuswanto *et al.*, 2017c). This maturity age range is broader than the promising lines derived from crossings grown in different soil types (Kuswanto, 2015), allowing finding a new gene source for developing variety.

Plant height, branches, and nodes have a relatedness because nodes is located on branches and main stem, and branches is located on the main stem. Plant height, number of branches, and reproductive nodes ranged from 49.87 to 98.09 cm, 3.07 to 4.53 branches, and 14.43 to 30.53 nodes per plant, respectively (Table 2). This study reveals a higher average of plant height but a lesser average of branches than Kuswanto (2015).

Number of filled and unfilled pods per plant ranged from 3.23 to 9.53 and 20.30 to 54.37, respectively. Averages of these two characters were 39.42 and 5.71 pods per plant, respectively (Table 2). The weight of 100 seeds had a range of values from 10.10 to 24.13 g (size medium to large seeds) with an average of 14.03 g. Seed

Table 1. Mean square of some agronomical characters

	MS _r	MS _g	MS _e	P _r	P _g
Days to flowering (days)	0.90	16.17	1.12	0.458	0.000
Days to maturity (days)	31.69	131.87	16.42	0.163	0.000
Plant height (cm)	33.30	389.78	44.91	0.485	0.000
Number of branches per plant	0.25	0.85	0.40	0.732	0.039
Number of reproductive nodes per plant	0.30	46.35	11.76	0.975	0.001
Number of filled pods per plant	16.40	193.84	78.60	0.813	0.017
Number of unfilled pods per plant	6.13	8.98	2.79	0.128	0.003
Weight of 100 seeds (g)	0.04	43.61	0.69	0.939	0.000
Seed yield (t/ha)	0.01	0.39	0.34	0.966	0.371

MS_r = mean square of replication, MS_g = mean square of genotype, MS_e = mean square of error, P_r = p value of replication, P_g = p value of genotype

Table 2. Minimum, maximum, and average values of some agronomical characters

	Minimum	Maximum	Average	SD
Days to flowering (days)	32.00	40.00	36.41	2.63
Days to maturity (days)	82.33	100.00	90.04	6.64
Plant height (cm)	49.87	98.09	70.53	12.72
Number of branches per plant	3.07	4.53	3.73	0.54
Number of reproductive nodes per plant	14.43	30.53	22.53	4.59
Number of filled pods per plant	20.30	54.37	39.42	9.98
Number of unfilled pods per plant	3.23	9.53	5.71	1.81
Weight of 100 seeds (g)	10.10	24.13	14.03	3.75
Seed yield (t/ha)	2.09	3.22	2.61	0.38

Table 3. Phenotypic coefficient of variation, genetic coefficient of variation, and genetic standard deviation of some agronomical characters

	PCV	GCV	SD genetic	Criteria
Days to flowering (days)	6.80	6.15	1.86	Broad
Days to maturity (days)	8.23	6.89	15.35	Narrow
Plant height (cm)	17.93	15.20	45.27	Narrow
Number of branches per plant	19.89	10.39	0.12	Broad
Number of reproductive nodes per plant	21.42	15.07	5.69	Broad
Number of filled pods per plant	27.44	15.72	26.16	Narrow
Number of unfilled pods per plant	38.58	25.16	1.14	Broad
Weight of 100 seeds (g)	27.61	26.97	4.99	Broad
Seed yield (t/ha)	22.91	4.95	0.07	Broad

yield ranged from 2.09 to 3.22 t/ha with an average of 2.61 t/ha (Table 2). The difference soybean genotypes grown in the same location reach 53.5 to 74.8 filled pods per plant (Kuswanto *et al.*, 2014), higher than this study, however, the grain size the previous study (Kuswanto *et al.*, 2014) is smaller.

Table 3 shows six characters of the nine characters observed which had broad GCV, i.e., flowering date, the number of branches per plant, number of reproductive nodes per plant, number of unfilled pods per plant, weight of 100 seeds, and yield. The other three characters (days to maturity, plant height, number of filled pods per plant) showed a narrow GCV. Broad variability will expand the opportunity to choose a character of excellence in breeding programs. The characters with narrow variability should be selected with a rigorous selection method to obtain the desired genotype. According to Akram *et al.* (2016), GCV value reflects the total amount of genotypic variability. However, the value of the PCV and GCV do not only serve to compare the number of contributing factors to the phenotype and genotype, but also very useful for assessing the capacity of improvement characters through selection.

All characters had a PCV value greater than GCV value (Table 3). This is an indication that the existing variability was not only influenced by genetic factors but it was also contributed by the environmental factors. The slight differences of PCV and GCV were seen in almost all the characters except the grain yield. This shows that the influence of environmental factors on the performance of phenotype is low (Aditya *et al.*, 2011; Malek *et al.*, 2014). Akram *et al.* (2016) stated that the low environmental factor causes a selection based on those characters will be effective. The studies of some author (Akram *et al.*, 2016; Baraskar *et al.*, 2014; Mahbub *et al.*, 2015; Nirmaladevi *et al.*, 2015) also showed the greater PCV than GCV with a small difference.

The coefficient of variance only shows the variability of the genotypes through the measured characters but does not provide information about the proportion of inheritance. Therefore, additional information about the heritability would be more efficient to determine the selection criteria to separate the environmental effect of the total diversity and as an accurate indication of the genotype identified on the nature of the phenotype (Osekita & Olorunfemi, 2014; Islam *et*

al., 2015). High heritability value on a character indicates that the total variability under genetic control, and selection based on the phenotypic level would be useful for the improvement of these characters (Akram *et al.*, 2016).

Broad sense heritability of the nine characters indicated the low to high heritability ranging 0.05 to 0.85 (Table 4). The character of grain yield was more influenced by environmental factors that can be seen from the low heritability value (0.05). The influence of genetic and environmental factors that contribute equally to the phenotypic performance shown by the character of number of branches, reproductive nodes, filled pods, and unfilled pods because these characters had medium heritability. High heritability values were reached by the character of days to flowering, days to maturity, plant height, and weight of 100 seeds. It means the performance of these four characters is predominantly influenced by genetic factors rather than environmental factors. The similar results are obtained by Jain *et al.* (2015) that reported that those four characters also have high heritability. The days to flowering and weight of 100 seeds with high heritability values are also obtained some authors (Aditya *et al.*, 2011; Osekita & Olorunfemi, 2014).

The broad GCV value followed by the high broad sense heritability would give good information to increase the success of the selection. In this study, the days to flowering and weight of 100 seeds had broad GCV and high heritability values. It means that those two characters are effective if used as selection criteria in breeding programs. According to Akram *et al.* (2016), the genetic factors governing these characters mostly have additive effects resulting in the effectiveness in soybean breeding program. Some studies also resulted the broad GCV and high heritability values on the character of number of pods (Ghodraati, 2013; Dilnesaw *et al.*, 2013; Kumar *et al.*, 2015;

Reni & Rao, 2013), plant height (Ghodraati, 2013; Dilnesaw *et al.*, 2013), number of branches, and seed yield per plant (Reni & Rao, 2013). Akram *et al.* (2011) suggested the characters of seeds yield, number of pods, number of branches, and plant height as the selection criteria because they have broad GCV, high heritability, and high genetic advance.

Days to flowering had significant positive correlation with plant height, number of branches, number of reproductive nodes, and number of pods. Plant height also had significant positive correlation with number of branches, number of reproductive nodes, and number of filled pods. Number of branches positively correlated with number of reproductive nodes and number of filled pods (Table 5). In this study varieties with high plant height tended to have high number of branches, reproductive nodes, and filled pods. Aditya *et al.*, (2011) stated that number of branches had a correlation with the number of pods.

Correlation analysis of all of the yield components had no significant correlation to the grain yield. In this study, the age character of flowering, plant height, number of branches, number of reproductive nodes, and number of filled and unfilled pods showed negative significant correlation with weight of 100 seeds (Table 5). Genotypes with early days to flowering, high plant height, high number of branches, many numbers of reproductive nodes tended to have a medium grain size. Contrary, genotypes with late days to flowering, medium plant height, a fewer number of branches and reproductive nodes were likely to have a large grain size. Based on these results the character of days to flowering, plant height, number of branches, number of reproductive nodes, and number of filled pods can be used as selection criteria for seed size. No significant correlation between the weight of 100 seeds and seed yield per plant was also reported by Akram

Table 4. Genetic variance (Vg), phenotypic variance (Vp), environment variance (Ve), and heritability of some agronomical characters

	Vg	Vp	Ve	H bs
Days to flowering (days)	5.02	6.14	1.12	0.82
Days to maturity (days)	38.48	54.90	16.42	0.70
Plant height (cm)	114.96	159.87	44.91	0.72
Number of branches per plant	0.15	0.55	0.40	0.27
Number of reproductive nodes per plant	11.53	23.29	11.76	0.50
Number of filled pods per plant	38.41	117.01	78.60	0.33
Number of unfilled pods per plant	2.06	4.85	2.79	0.43
Weight of 100 seeds (g)	14.31	15.00	0.69	0.95
Seed yield (t/ha)	0.02	0.36	0.34	0.05

Table 5. Correlation between agronomical characters

	DTM	PHT	NOB	NRN	NFP	NUP	W100	SYD
DTF	0.341	0.916**	0.675**	0.802**	0.584*	-0.196	-0.814**	0.309
DTM		0.215	-0.001	0.047	-0.094	-0.548*	0.146	0.083
PHT			0.715**	0.798**	0.638**	-0.220	-0.758**	0.330
NOB				0.802**	0.563*	-0.094	-0.640**	0.147
NRN					0.778**	-0.090	-0.824**	0.180
NFP						-0.166	-0.770**	0.081
NUP							-0.017	-0.257
W100								-0.300

DTF = Days to flowering (days), DTM = Days to maturity (days), PHT = Plant height (cm), NOB = Number of branches per plant, NRN = Number of reproductive nodes per plant, NFP = Number of filled pods per plant, NUP = Number of unfilled pods per plant, W100 = Weight of 100 seeds (g), SYD = Seed yield (t/ha)

et al. (2011). It indicates that those two characters are genetically independent of each genotype. Mahbub *et al.* (2015) also reported similar result, where plants with a high plant height and many numbers of pods have small seed size.

The implications of the results of the study suggest that genetic improvements can still be performed on days to flowering, number of branches, number of reproductive nodes, number of unfilled pods, weight of 100 seeds, and seed yield if using the 16 tested varieties as plant materials, due to the high genetic diversity obtained in those characters. Beside, selection of the cross-breeding will be easy to do in characters of day to flowering, days to maturing, plant height, and weight of 100 seeds because they had high broad sense heritability. The benefit of using these varieties is that these sixteen varieties have different superiority. Therefore, they can be combined each other with few accompanying disadvantage, so the selection for the best combination will be easier.

CONCLUSION

GCV is important in the development of a new plant variety by estimating the genetic variability of the plant materials. The broad GCV was achieved in the days to flowering, number of branches, number of reproductive nodes, number of unfilled pods, weight of 100 seeds, and yield, while narrow GCV was obtained on the days to maturity, plant height, and number of pods. Except for the seed yield, PCV and GCV revealed a little differences. Heritability is also essential in plant breeding by estimating genetic inheritance. The high broad sense heritability was recorded on days to flowering, days to maturing, plant height, and weight of 100 seeds. Medium broad sense

heritability was observed on the number of branches, number of reproductive nodes, and number of filled and unfilled pods. The low broad sense heritability was only obtained on the seed yield. Days to flowering and weight of 100 seeds are the most effective characters used as selection criteria because they had a broad GCV and high heritability. Yield components were negatively correlated with the weight of 100 seeds, and there was no correlation between yield and yield components.

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