Selection of F4, F5 and F6 Soybean Breeding Lines for High Yield and Large Seed Size

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Abstract

The first step in a cultivar development is to form a population with genetic variability for the characters of interest. This is done by hybridization of genetically different parents. Hybridization was made to combine the characters of high yield potential, wide adaptability, desirable agronomic characters, and large seed size by using cv. Tanggamus, Sibayak, Argomulyo, Anjasmoro, Panderman and Local Tegal. Amount of 4800 F4 lines originated from five single cross combination were planted in rice field, Sukawening, Garut District, West Java on early dry season 2007. Pedigree method of selection was used. Each line was grown in one row of three meters length and 40 cm between rows. There was a high variability on agronomic characters (plant height, pod number, seed yield and seed size). Amount 1311 F5 lines were selected and grown in the same location on late dry season 2007. Amount of 540 F6 lines were selected and grown in the same location on early rainy season 2007/2008. Sixty-two F7 lines were selected, and 42 lines among them had high yield and large seed size.

Keywords: high yield, large seed size, soybean breeding lines

Introduction

Breeding for high yield potential is generally the major goal in any breeding program including soybean. Breeding for high yield potential is inextricably linked with breeding for other characteristics. Today the preferences of users (farmers and craftsmen tempeh and tofu) were more likely to require large varieties of soybean seed. Craftsmen tempeh and tofu have long accustomed to using large seed soybean imports, so that preferences are now a lot towards the large seed.

To meet user demand, then breeding programs to produce varieties of soybean large seed in major need of attention. A number of varieties of large seed soybean have been available such as Argomulyo, Burangrang, Anjasmoro, and Grobogan (Hermanto et al., 2009).

As an effort to produce new varieties of soybeans that are superior to the existing varieties, a number of crossing (hybridization) between soybean genotypes of high yield potential, quite broad adaptability, many pods and smaller seed size with the genotypes of relatively low yield potential, narrow adaptability, few pods, and large seed size, and were carried out in 2004 (Arsyad et al. 2005).

This study aimed to: (a) obtain expected breeding lines better than the existing varieties, which possess higher yield potential, desirable agronomic traits and has a large or slightly larger seed size, and (b) study the behavior of the relationship among traits in soybean.

Materials and Methods

Plant Materials

Selection of F4, F5 and F6 soybean breeding lines was conducted in the rice field of Sukasono Village, Sukawening Subdistrict, Garut District, at the growing season I (April-June 2007), season II (July-September 2007) and the season III (September-November 2007), respectively. Selection materials that were used in the firs selection In the season I the 4800 F4 soybean breeding lines were grown and selected. Those breeding lines were derived from a combination of five single crosses, which were Tanggamus x Tegal, Tanggamus x Anjasmoro, Sibayak x Tegal, Sibayak x Argomulyo, and Sibayak x Panderman, made in 2005 (Arsyad et al. 2005). In season II,

the 1311 F5 breeding lines wich were selected from the F4 lines in season I, were grown and then as many as 540 F6 lines were selected. Those 540 F6 lines were grown in season III.

Methods

Pedigree method based selection was used in each generation (Fehr, 1987). In each season, each breeding lines was grown as a single row with 1.5 meters length. Spacing between rows (lines) were 40 cm and 10 cm within rows, and one seed/hole. Intensive techniques cultivation involves fertilizing with 75 kg urea, 200 kg SP36, and 150 kg KCl per ha, controlling of weeds, pests and diseases were carried out. Irrigation was applied, if there is no rain. The selection criteria was an ideal plant type,i.e. sturdy plants (not fall), plant height > 70 cm with 4-5 branches, medium leaf size, determinate type, more than 70 pods/plant and large pods. Selection procedure was done as follows: First, selected the good rows of plants, and secondly, selected the 3-5 plants in selected row that meet the selection criteria. Each selected individual plant was a new breeding line to the next generation. Data analysis was done by creating the frequency distribution of selected breeding lines, calculate the mean and standard deviation for the observed characters of each population, as well as t test for mean population comparation (Gomez & Gomez 1984, Sugiyono 2009).

Results and Discussion

Selection of F4 Lines

Before time to harvest, around 1600 lines was selected and then as many as 1311 lines was selected based on yield and seed quality. Only breeding lines derived from three crossing combinations were selected. Those were the crosses between Sibayak x Tegal (Code V), Tanggamus x Tegal (Code U) and Sibayak x Argomulyo (Code W). The other two crosses (Tanggamus x Anjasmoro and Sibayak x Panderman) derived inferior progenies. .

Frequency distribution of selected breeding lines based on crop yield are presented in Figures 1. The range of lines seem still very wide, ranging from less than 10 g to more than 50 g/line, with the highest frequency was in the range of 21-25 g/line. Genotype of parents produuced average yield of less than 20 g/genotype. This indicated the presence of transgressive segregation on the breeding materials. Variability was also found in the seed size (100 seed weight), plant height, and number of pods (Figure 2-4). The selection would be effective when there was wide phenotypic variability among breeding lines. This was understandable because the selected lines were still at F4 generation and was not selected since F2. The frequency of heterozygous individuals at a locus was 50% in F2 (Fehr 1983), and because the selection has not been done since the F2, therefore the heterozygote frequency in the F4 was still high (50%).

Breeding lines derived from Sibayak x Tegal cross have an average higher yields, larger seed, higher plant, but the number of pods is less than the breeding lines derived from Tanggamus x Tegal and Sibayak x Argomulyo (Table 1). No yield different between breeding lines derived from Tanggamus x Tegal and Sibayak x Argomulyo. Breeding lines derived from Sibayak x Tegal has larger seed size compared to the breeding lines derived from Tanggamus x Tegal and Sibayak x Argomulyo. Breeding lines derived from Sibayak x Argomulyo had a relatively smaller seed size compared to the other two cross combinations, but it had more pods per plant. It appears a tendency that the breeding lines of a large seed pods had fewer seeds, while breeding lines of moderate or relatively small seed pods had more seeds.

A total of 203 breeding lines have been identified with high yield capacity, which was more than 30 g/line (data not presented). A total of 99 breeding lines of which had large seed size (>13g/100 seeds), and the other 104 breeding lines had moderate or relatively smaller seed size. Selection will change the frequency of genotype and phenotype of a locus (Ferhr 1983). The basis of the expected effect of the selection is the change of gene frequencies (Falconer, 1967), but we do not know what the frequency of genes that changed, because the selection was only based on phenotypic selection. The selection would be effective to choose recessive alleles, as consequently in one generation all dominant alleles will be eliminated in the population. However, if the selection is intended to eliminate the recessive alleles, it would be more difficult because it is covered by dominant alleles in the heterozygous individuals (Fehr, 1983).

Although the selection in this study was only based on phenotypic values, it was expected to be quite effective to gain the best selected lines, which is expected to produce good progenies. The progress of the selection is determined by phenotypic variability, heritability values and selection intensity (Falconer, 1967). Agronomic characters such as plant height, number of branches and number of pods support high capacity of selected the breeding line.

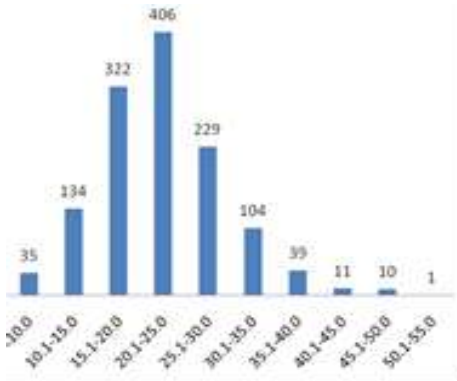

Figure 1. Frequency distribution of F4 soybean breeding lines for yield (g/plant), Garut, season I 2007.

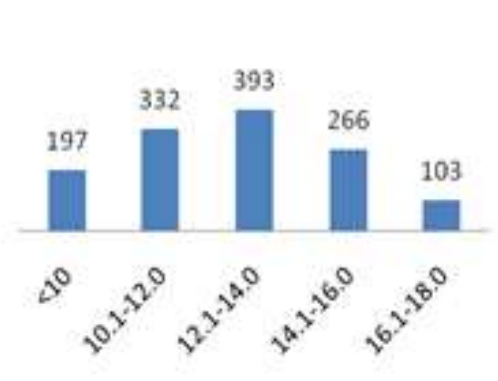

Figure 2. Frequency distribution of F4 soybean breeding lines for 100 seed weight (g), Garut, season I 2007.

Figure 3. Frequency distribution of F4 soybean breeding lines for plant height (cm), Garut, season I 2007.

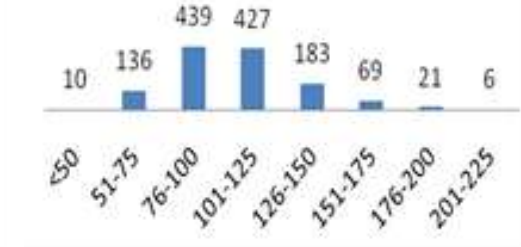

Figure 4. Frequency distribution of F4 soybean breeding lines for pod number per plant, Garut, season I 2007.

Table 1. Mean and standar deviation of seed yield, 100 seed weight, plant height, and number of pods per plant of F4 lines originated of three single cross in rice field at Sukasono Village, Sukawening Subdistrict, Garut District, early dry season of 2007

Population	Number of lines	Seed yield (g)	100 seed weight (g)	Plant height (cm)	Number of pods / plant
V (Sibayak x Tegal)	490	24a ± 7.1	14.1a ± 2.1	58a ± 9.2	97b ± 25.4
U (Tanggamus x Tegal)	400	22b ± 6.8	12.6b ± 1.9	51b ± 8.1	100b ± 24.4
W (Sibayak x Argomulyo)	401	22b ± 7.3	10.9b ± 2.2	56a ± 7.6	124a ± 29.5

Value in the same column followed by the same letter are not different at 0.01 probability level

Selection of F5 Lines

Before time to harvest around 700 lines was selected and, as many as 540 lines was selected based on yield and seed quality. Frequency distribution of breeding lines on several classes of seed yield is presented in Figure 5. The yield range of the breeding lines seemed quite wide, ranging from less than 10 g to more than 30 g/line, with the highest frequency present in the range of 11-15 g/line. The parent produced an average yield of less than 11g. A total of 191

breeding lines produced higher yield than that of the best parent (Tanggamus). This indicated the presence of the transgressive segregation, i.e. breeding line yields were higher than that of both parents. The occurence also the same as the seed size (100 seed weight), which was as many as 88 breeding lines contained a rather large to large seed size (Figures 6). Plant height and number of pods showed a fairly high variability (Figure 7 and 8).

Breeding lines derived from Sibayak x Argomulyo had the higher average yields, higher plant height, and more pods per plant than those of the breeding lines derived from Tanggamus x Tegal and Sibayak x Tegal (Table 2). In contrast, breeding lines derived from Sibayak x Tegal produced average seed size larger than that of the breeding lines derived from Tanggamus x Tegal and Sibayak x Argomulyo. It was a tendency that the breeding lines of larger seed correlated with fewer pods, shorter plants and lower grain yield. The selection would be effective when the high variability occurred among breeding lines. A total of 62 breeding lines had high yield capacity (Table 3).

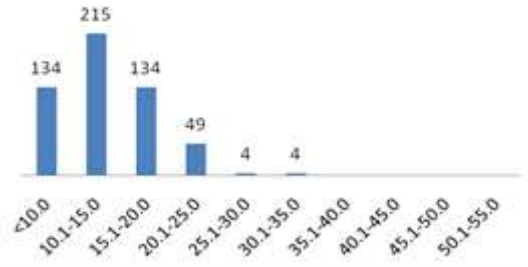

Figure 5. Frequency distribution of F5 soybean breeding lines for yield (g/plant), Garut, season II 2007.

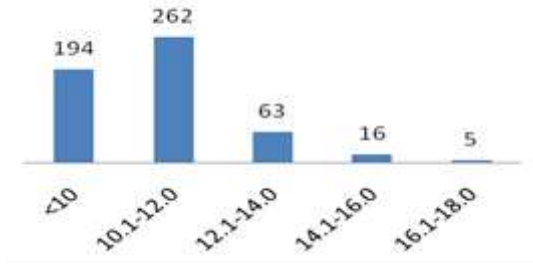

Figure 6. Frequency distribution of F5 soybean breeding lines for 100 seed weight (g), Garut, season II 2007.

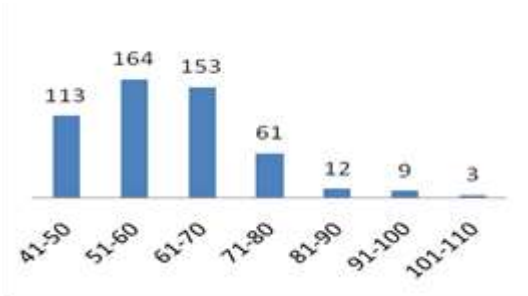

Figure 7. Frequency distribution of F5 soybean breeding lines for plant height (cm), Garut, season II 2007.

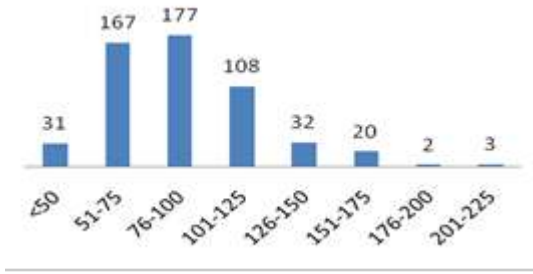

Figure 8. Frequency distribution of F5 soybean breeding lines for pod number per plant, Garut, season II 2007.

Selection of F6 Lines

Of the 540 F6 breeding lines that were selected in the experiment on season III 2007, 100 breeding lines were selected at the harvesting time, and the best 60 breeding lines were selected after processing. Of the 60 F7 breeding lines, as many as 42 breeding lines had the high yield capacity and relatively large seed (Table 4). Among the 42 breeding lines, 16 breeding lines were derived from the cross between Sibayak x Tegal, six breeding lines were derived from the cross between Tanggamus x Tegal, and 20 breeding lines were derived from teh cross between Sibayak x Argomulyo cross. Those breeding lines will be tested further in the preliminary yield testing on early dry season of 2008.

Table 2. Mean and standar deviation of seed yield, 100 seed weight, plant height, and number of pods per plant of F5 lines originated of three single cross in ricefield at Sukasono Village, Sukawening Subdistrict, Garut District, late dry season of 2007

Population	Number of lines	Seed yield (g)	100 seed weight (g)	Plant height (cm)	Number of pods / plant
V (Sibayak x Tegal)	200	14b ± 4.9	11.1a ± 1.5	64b ± 12.3	79b ± 25.5
U (Tanggamus x Tegal)	200	12b ± 4.1	10.8b ± 1.5	50c ± 7.8	79b ± 22.8
W (Sibayak x Argomulyo)	140	18a ± 4.6	9.9b ± 1.5	68a ± 8.7	119a ± 27.2

Value in the same column followed by the same letter are not different at 0.01 probability level

Table 3. Performance of the best 62 F5 breeding lines in ricefield at Sukasono Village, Sukawening Subdistrict, Garut District, season II 2007

Breeding line	Number of lines	Plant height (cm)	Number of branches per plant	Number of pods per plant	Seed yield (g)	100 seed weight (g)
V (Sibayak x Tegal)	20	62 (46-100)	6.8 (4-10)	107 (77-240)	23.3 (21.2-26.4)	11.7 (9.9-14.9)
U (Tanggamus x Tegal)	11	53 (40-61)	6.9 (4-10)	111 (75-145)	21.8 (20.6-23.4)	10.9 (8.4-13.3)
W (Tanggamus x Argomulyo)	31	69 (57-102)	6.5 (4-8)	148 (109-239)	23.8 (20.2-35.1)	13.0 (8.8-17.40
Tanggamus	-	50	5	68	10.7	9.2
Sibayak	-	56	5	86	10.0	9.8
Tegal	-	39	2	27	4.4	17.2
Argomulyo	-	40	5	52	8.9	13.3

Value in parenthese is a range

Table 4. Agronomic performance and seed yield of 42 F6 soybean breeding lines selected in ricefield at Sukasono Village, Sukawening Subdistrict, Garut District, season III 2007

No.	Breeding line	Plant height (cm)	Number of branches	Number of pods	Seed yield (g)	100 seed weight (g)
1	V-5-1-1-2	69	5	99	25.1	14.9
2	V-43-2-2-1	95	4	77	22.1	14.9
3	V-63-2-1-1	68	7	102	26.2	13.9
4	V-75-2-1-2	69	6	114	27.7	14.7
5	V-75-2-3-1	68	4	85	25.4	14.8
6	V-75-2-4-2	65	4	91	23.0	13.0
7	V-250-2-2-1	66	7	106	26.7	13.3
8	V-257-1-1-1	62	9	123	26.4	14.4
9	V-273-1-1-2	70	7	114	25.7	13.0
10	V-284-2-1-1	66	8	117	25.4	13.8
11	V-215-1-1-1	62	9	113	22.1	14.3
12	V-215-1-2-1	62	7	240	30.3	13.4
13	V-215-1-4-1	58	8	118	25.4	14.3
14	V-390-2-3-2	59	7	120	24.8	13.1
15	V-424-1-1-2	60	10	104	25.3	13.3
16	V-612-2-1-2	66	7	110	23.5	13.6
17	U-574-1-1-1	64	8	104	20.8	13.3
18	U-445-2-1-1	60	7	122	22.1	14.5
19	U-79-2-2-2	58	5	123	20.6	12.5
20	U-675-1-1-1	56	8	93	21.3	12.2
21	U-534-2-2-1	62	4	106	22.3	12.9
22	U-697-1-1-1	54	7	99	21.5	13.4
23	W-209-1-1-2	68	8	170	20.8	13.1
24	W-455-1-2-1	98	6	120	22.4	15.4
25	W-460-1-1-1	70	5	109	21.3	13.6
26	W-47-2-1-1	68	6	130	20.3	13.0
27	W-466-1-1-1	70	7	191	32.2	13.1
28	W-40-1-1-2	67	7	147	27.6	14.3
29	W-40-1-2-2	65	8	127	24.0	13.3

No.	Breeding line	Plant height (cm)	Number of branches	Number of pods	Seed yield (g)	100 seed weight (g)
30	W-165-1-1-1	75	7	168	25.7	13.7
31	W-284-1-3-1	72	8	239	34.3	13.4
32	W-537-1-1-1	67	4	103	21.2	13.6
33	W-267-2-1-2	74	5	100	20.0	14.5
34	W-530-1-2-1	67	6	145	25.3	13.3
35	W-308-2-1-2	71	7	180	35.1	13.3
36	W-258-1-1-1	86	5	127	24.0	13.9
37	W-271-1-1-1	70	8	158	21.1	12.6
38	W-519-1-2-1	79	8	175	25.1	13.1
39	W-169-1-2-1	68	6	160	30.8	12.7
40	W-304-1-2-1	64	7	138	22.3	12.5
41	W-304-1-3-1	66	7	176	21.2	13.3
42	W-197-1-1-2	59	6	142	23.3	13.8
43	Tanggamus	58	6	68	10.7	10.2
44	Sibayak	60	6	86	10.0	11.1
45	Tegal	45	3	36	14.2	17.0
46	Argomulyo	54	5	58	18.5	14.6
	V (16 lines)	67	6,8	114	25.3	13.9
		(58-95)	(4-10)	(77-240)	(22.1-30.3)	(13.0-14.9)
	U (6 lines)	59	6,5	108	21.4	13.1
		(54-64)	(4-8)	(93-123)	(20.6-22.3)	(12.2-14.5)
	W (20 lines)	71	6,5	150	24.9	13.5
		(59-98)	(4-8)	(100-239)	(20.0-35.1)	(12.5-15.4)
	Check (4 var.)	54	5	62	13.4	13.2
		(45-60)	(3-6)	(36-86)	(10.0-18.5)	(10.2-17.0)

V= Sibayak x Tegal cross
U= Tanggamus x Tegal cross
W=Sibayak x Argomulyo cross
Value in parenthese is a range

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