International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Selection for the Increasing Yield of Purple and Yellow Pod Beans (*Phaseolus vulgaris* L.) on F_2 Generation

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Abstrack: ***The objective of the research was to acquire new line of purple and yellow pod beans which has a high yield. This research was carried out in May to August 2013. The experiment organized by single plant method without replication and the treatment are 8 F_2 population from a cross combinations elder and 5 parental varieties. Method of the selection is pedigree selection with the selection criteria include pods color and high yield. Data of the observation was analyzed to find out the environmental variance, genetic variance, heritability, selection progress for each selected line and organoleptic test. Results of this research showed that out of 864 lines of the grown plants, 163 selected lines were obtained that consisted of 74 purple pods lines and 89 yellow pods lines. High value of the genetic progress for pods weight character per plant has been belonged to all lines that can be selected effectively to improve the yield in F3.***

Keywords: Beans, selection, pod color, yield, genetic progress.

1. Introduction

Beans (*Phaseolus vulgaris* L.), which is well-known as bean, belong to legumes that having more benefits. Bean is one of vegetable protein sources, which is cheap. The demand of beans keep increasing year-by-year along with the rapid growth of population. The statistical data on beans production in Indonesia during the period of 2008 was 242.45 tons. The average yield of beans in 2009 was 8.52 ton ha^{-1} [1]. The increasing number of populations led to the increasing demand of beans, while the domestic production has not been sufficient to fulfill the demand.

The increasing production and quality of beans should be done in order to fulfill the national food requirements. The main cause of failure in increasing the production, in the farmer level, is the pest infection and repeated varieties applications and descending without passing through tight selection, which causes the declined quality of the yield. In general, the farmers have not been interested to change local variety before they ascertain that the new variety is more superior and beneficial than the former, so that such new variety introduction may offer some challenges, such as insufficient initial supply of seeds and limited range of the seed supply [2].

Bean is not the origin plant of Indonesia, so that the genetic sources would be limited as well, and it can be overcome by importing an introduced variety. One of efforts to increase variances is crossing the introduced varieties of bean. The introduced varieties in this research were Purple Queen and Cherokee Sun. Selecting both introduced varieties were based on superiority belongs to each variety. Purple Queen has purple color because it contains anthocyanine and Cherokee Sun has yellow pods due to carotene.

Based on diverse superiorities of local beans and the introduced ones, it has initiated an idea to combine superiorities of local beans and the introduced ones through hybridization, which is expected to be one of the national superior variety candidates. The bean-hybridization product will be selected to obtain the suitable product as desired, purple and yellow pods, which produce high yields. A part of the cross-breeding of both beans has produced purple and yellow pod beans, but in low yields as shown in number of pods per plant, therefore, a breeding program is required, such as selection, to increase quality of the cross-breeding.

Plant breeding is an effort to improve shape and properties of the plant in order to create new varieties that having better properties than the parent, based on the production and resistant to any disease. Variety improvement can be done by combining the desired genetic properties, and one of them is through cross-breeding, improving and utilizing the genetic variances, then followed by selection and evaluation on the yields. The objective of such breeding is to obtain new varieties along with better hereditary properties/traits than the parents.

The genetic variance in breeding program is the key to reach success in selection process. Cross-breeding between parents with different traits will create greater genetic variances. Such greater genetic variances will increase the median value of the selection in the next generation. Therefore, success in establishing F2 that having greater genetic variances highly determine the genetic progress, which is going to be resulted in selection process.

2. Materials and Methods

The research was conducted at Junrejo Village, Junrejo Subdistrict in Batu at the altitude of ± 760 m asl, which having the rainfalls of ± 1300 mm/yr, daily-mean

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temperature ± 22°C. The research was done from 1st May 2013 – 8th August 2013.

This research is an intermediate research on Hereditary Traits Pattern in Pod Colors on the Cross-breeding Products between the Introduced-and-Local Varieties (Oktarisna, 2013). The research suggested no maternal effect on the cross-breeding products between the Purple Queen and local varieties, so that it is not necessary to separate the derivatives of F2 and the reciprocals. Cross-breeding between the Cherokee Sun and local varieties has produced the maternal effect, so that data analysis was done on each F2 of Cherokee Sun's heredities and their reciprocals.

Equipments of the research include farming tools, documentation devices, such as camera, labels, paper bags, marker, and analytic scales, sliding calipers, as well as rulers. Planting materials include 5 parental varieties (3 local varieties and 2 introduced varieties) as control, and F_2 of each parental crossbred combination. Local parental varieties include *Gogo Kuning, Gilik Ijo,* and *Mantili*, while the introduced varieties include Purple Queen and Cherokee Sun. Application of the fertilizers are stable manures and NPK.

The research was arranged in single plant by planting all lines and the parents in a plot at the same planting environment without any replication. As the treatment is 8 lines of F_2 from crossbred combination of the parents and 5 parental varieties. GI x CS is lethal or having incompatility, so that no heredity of GI x CS.

Table 1: Planting materials

Parent	*F_2*	
• Gilik Ijo (GI) • Gogo Kuning (GK) • Mantili (M)	• PQ x GI • PQ x GK • PQ x M	
• Cherokee Sun (CS) • Purple Queen (PQ)	• CS x GI • CS x GK • CS x M	• GK x CS • M x CS

Method of the selection used a pedigree selection. The selection was based on the purple pods, greenish purple, yellow and greenish yellow, which produced high yields. Selection by choosing individuals that produce high yields would be done by comparing them with the mean values of both parents and the mean of the national superior varieties (*Balitsa 1, Balitsa 2,* and *Balitsa* 3). Each selected line will be numbered in order to facilitate the selection in the next step.

3. Results and Discussions

3.1 Selected Plants

Based on the selection, out of total 864 lines, 163 lines have been selected, which include 74 lines of purple pods and 89 lines of yellow pods. Results of the selection show that 74 lines of purple pods were derived from the Purple Queen x *Gilik Ijo* for about 32 lines, Purple Queen x *Gogo Kuning* for about 20 lines, and Purple Queen x *Mantili* for about 22 lines. While results of the selection on 89 lines of yellow pods were derived from the Cherokee Sun x *Gilik Ijo* for about 18 lines, Cherokee Sun x *Gogo Kuning* for about 15 lines, and Cherokee Sun x *Mantili* for about 20 lines. *Gogo Kuning* x Cherokee Sun have 30 lines and *Mantili* x Cherokee Sun have 6 lines. Basic in selecting each line, based on the colors of pod, purple or yellow, as well as the pod yield per plant as compared with the parents and the national superior varieties. Each population F_2 has high color variances due to having maximum segregation. Variance in pod colors is presented in the Table 2.

All populations F_2 showed that almost a half of the grown plants have purple or yellow colors. Some of the available populations showed variances in color and shape of the pods. For instance, in CSM population, almost all populations are yellow and a few has greenish yellow. This is analogous to populations of PQGI and PQGK, in which almost all populations are purple. Variances beans, as a result of selection, are shown that based on character colors of the pods, purple or yellow, the pod yield per plant, which are compared with the parents and national superior varietas and the pod shapes.

Based on observation in the field, it is found out that morphological traits variances in beans are very high. The observed variances are based on color and taste of the pods. Based on observation over the selected beans as a result of crossbred between local and Purple Queen, and it shows diverse colors of purple that can be grouped into 5, such as deep purple, purple, and greenish purple, as well as light purple. Observation on the selected beans, as a result of crossbred between the local beans and the Cherokee Sun, shows diverse colors of pods. F_2, as a result of crossbred between Cherokee Sun x *Gogo Kuning* and Cherokee Sun x *Mantili*, has diverse colors for its pods, such as deep purple, greenish purple, yellow, deep purple, light yellow, greenish yellow, and brownish yellow.

Not only the pods, but also the stems have different colors on each line and diverse individual plant as well. There are plants that have dominant color of green in the stems with the surface parts are purple when they expose the sunrays, and green stems with purple stripes, as well as dominant colors of purple or deep purple in the stems. Plants that have purple stems do not always produce purple pods, as well as the green stems. Colors of leaf and the growing type on F_2 are different as well. In general, the leaf color of the purple pod beans tends to be deeper in comparison with both yellow and green pods. The growing types of beans are divided into 2, such as creeping and standing upright. However, twisted upright type has also found in this research. Such twisted type is marked in the initial growth, which looks stand upright, but the spiraling shoots emerge and start to twist entering into the generative phase.

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Table 2: Numbers for each pod color in each population

Popu-lation	*U*	*UC*	*UT*	*UH*	*H*	*HC*	*HU*	*HKE*	*HKM*	*K*	*KH*	*KK*	*Total*
GIPQ	248	11	13	33	15	2	3	0	0	0	0	0	325
GKPQ	129	2	28	12	24	1	7	0	0	0	0	0	203
MPQ	20	3	1	14	21	3	7	0	0	0	0	0	69
GKCS	12	0	15	20	30	12	7	1	1	2	0	0	205
MCS	1	0	1	6	6	4	1	0	0	1	0	0	20
CSGI	0	0	0	0	31	10	0	0	0	18	4	0	63
CSGK	0	0	0	0	23	24	0	0	0	49	7	2	105
CSM	0	0	0	0	0	0	0	0	0	89	10	0	99

Note: **U**=purple; **UC**:Bright Purple; **UT**: Deep Purple; **UH**: Greenish Purple; **H**:Green; HC:Bright green; HU:Light Green; HKE: Yellowish Green; HKM: Reddish Green; K: Yellow; KH: Greenish Yellow; KK: Brownish yellow

Genetic Variance and Expected Genetic Progress

The research in this selection is based on the purple and yellow pods. Both purple and yellow pods beans are potential due to have specific characteristics in comparison with ordinary beans that having light green pods. It is expected that such specific characteristics would be able to add the selling price of the beans. Besides having different color, the nutrient content is higher. High genetic variance is one of requirements in the success of selection on the desired character. According to [3], improvement of a character by selection will be run well if greater genetic variances existed in a population. [4] stated that in order to learn a character, besides the genetic variances, it required other genetic parameter, such as heritability. Wide genetic variances guarantee the effectiveness of the selection program on the selected genotypes and effective selection will make it to be more efficient if the estimated value of the heritability characters is high enough.

Table 3: Variance of each character

Lines		*Pod Length*	*Pod Diameter*	*Pod Weight*	*Flowering Time*	*Fresh Harvest*	*Numbers of Pod per Plant*	*Pod Weight per Plant*
PQGI	σ2 environment	1,55	0,01	1,70	7,05	1,18	108,20	11498,20
	σ^2	2,47	0,01	2,49	11,30	10,86	289,10	15161,91
	h^2	0,37	0,28	0,32	0,38	0,89	0,63	0,24
PQGK	σ2 environment	1,70	0,00	1,75	7,12	1,35	62,74	11279,78
	σ^2	3,71	0,01	3,77	15,27	13,14	312,35	13135,11
	h^2	0,54	0,20	0,54	0,53	0,90	0,80	0,14
PQM	σ2 environment	1,51	0,00	1,65	6,18	1,23	60,96	9895,52
	σ^2	5,33	0,03	2,25	13,93	7,46	183,99	14719,45
	h^2	0,72	0,86	0,27	0,56	0,84	0,67	0,33
CSGI	σ2 environment	0,58	0,01	0,63	6,13	1,31	128,59	6917,47
	σ^2	1,60	0,01	1,44	16,69	14,01	713,04	35507,07
	h^2	0,64	0,27	0,56	0,63	0,91	0,82	0,81
CSGK	σ2 environment	0,76	0,00	0,62	6,17	1,61	54,51	6171,70
	σ^2	1,44	0,01	0,73	10,52	11,77	174,39	6346,66
	h^2	0,47	0,66	0,15	0,41	0,86	0,69	0,03
CSM	σ2 environment	0,80	0,00	0,85	5,13	1,35	54,68	5874,91
	σ^2	0,88	0,01	0,90	10,56	8,83	110,68	6407,11
	h^2	0,09	0,40	0,05	0,51	0,85	0,51	0,08
GKCS	σ2 environment	0,76	0,00	0,62	6,17	1,61	54,51	6171,70
	σ^2	5,86	0,03	2,15	10,01	15,95	206,92	17145,96
	h^2	0,87	0,89	0,71	0,38	0,90	0,74	0,64
MCS	σ2 environment	0,80	0,00	0,85	5,13	1,35	54,68	5874,91
	σ^2	3,01	0,01	1,18	21,46	21,73	978,75	42610,31
	h^2	0,73	0,70	0,28	0,76	0,94	0,94	0,86

The expected genetic progress can be used as estimator of the increasing values of non-uniform genetic characters from the mean values of genetic as a result of selection and the extent of intensity. High heritability, followed by high selective responses, is resulted by the works of the additive genes. On the contrary, properties that having high heritability and followed by lower selection response, are resulted by non additive gene (dominant, epistasis). Such high heritability value is caused by maximum level of segregation in population F2 [5].

According to [6], the extent of genetic progress has gone along with the transgressive segregation hypothesis, in which the yield character was controlled by double-gen system that worked dominantly, and genotypes, which accumulated more dominant genes, have higher yield.

Based on the obtainable data, it showed that F_2, as a result of crossbred between the Purple Queen x *Gilik Ijo*, which has medium to high heritability values for all of the observed characters. Characters for number of pods per plant have high heritability values, which mean that those characters are potential to be selected. Characters for number of pods per plant and pod weight per plant have high percentage values for the genetic progress. Selection to improve or increase the yields can be done on characters for number of pods per plant that have genetic progress of 86%. It means that if the selection would be more effective on number of pods per plant, which could increase the average number of pods, from 21 pods per plant to 38 pods per plant. The increasing number of pods per plant would significantly increase the yield, even though without any increasing weight of each pod.

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Table 4: Genetic progress of the purple pods

Line	*Data*	*Mean*	*h2*	*Criteria*	*Selection Progress*	*Genetic Progress*	*Criteria*
PQGI	Pod length	16,44	0,37	Medium	1,03	6,28	Low
	Pod diameter	0,96	0,28	Medium	0,04	4,55	Low
	Pod weight	8,41	0,32	Medium	0,88	10,48	Medium
	Flowering time	35,57	0,38	Medium	2,22	6,25	Rendah
	Fresh harvest time	47,88	0,89	High	5,17	10,80	Medium
	Number of pods per plant	21,58	0,63	High	18,72	86,77	High
	Pod weight per plant	171,23	0,24	Medium	52,37	30,58	High
PQGK	Pod length	16,53	0,54	High	1,84	11,11	Medium
	Pod diameter	1,00	0,20	Medium	0,03	2,79	Low
	Pod weight	8,69	0,54	High	1,83	21,10	High
	Flowering time	35,64	0,53	High	3,67	10,30	Medium
	Fresh harvest time	47,70	0,90	High	5,73	12,00	Medium
	Number of pods per plant	21,21	0,80	High	24,86	99,93	High
	Pod weight per plant	167,35	0,14	Low	28,49	17,03	High
PQM	Pod length	15,88	0,72	High	2,91	18,33	High
	Pod diameter	0,98	0,86	High	0,27	27,48	High
	Pod weight	8,45	0,27	Medium	0,70	8,33	Medium
	Flowering time	34,32	0,56	High	3,65	10,64	Medium
	Fresh harvest time	46,84	0,84	High	4,02	8,57	Medium
	Number of pods per plant	30,16	0,67	High	15,96	52,93	High
	Pod weight per plant	253,49	0,33	Medium	69,98	27,61	High

Most of the Purple Queen x *Gogo Kuning* lines has high heritability for almost all of the observed characters, except diameter of the pod, which has medium heritability value. Characters, which refer to the yield, such as weight of each pod and number of pods per plant, have high heritability values. Selection on these lines could be done effectively by increasing weight of each pod or increasing number of pods per plant, which would lead to the increasing yield per plant. High percentage of the genetic progress is shown on character for number of pods per plant, 99.9%, therefore such selection to increase the yield of this line can be done on character for number of pods per plant. The Purple Queen x *Mantili* lines have high heritability for characters, which support the yield, such as the pod length, pod diameter, and number of pods per plant. Character for weight of pod per plant shows medium heritability value even though percentage of the genetic progress is high, therefore, the selection to ibcrease the yield can be done on characters, such as number of pods per plant or weight of pod per plant. The increasing number of pods per plant without being accompanied with the increasing weight of each pod could increase the yields.

The effective selection to increase the yield in this line can be done by characters such as number of pods per plant and weight of pod per plant. Character for the pod length has high genetic progress, 18.33%, but it cannot be used as criteria of selection due to based on result of the taste test, most of the respondents do not like long pod. That is why this character is excluded in the criteria of selection.

The Cherokee x *Gilik Ijo* lines have high heritability for almost all of the observed characters, except diameter of pod, which has medium heritability. It shows that variances on those characters are highly affected by the genetic factor. High genetic progress on some characters shows that those characters can be selected effectively to increase the yield. Character of weight for each pod, even has high genetic progress, but the value is higher than the character for number of pods per plant and weight of pod per plant. High percentage of genetic progress is found on character for number of pods per plant and weight of pod per plant, therefore selection to increase the yields of this line will be effective if it is done on those three characters.

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Table 5: Genetic progress of the yellow pods

Line	*Data*	*Mean*	*h2*	*Criteria*	*Selection Progress*	*Genetic Progress*	*Criteria*
CSGI	Pod diameter	0,96	0,27	Medium	0,04	4,15	Low
	Pod weight	6,64	0,56	High	1,18	17,80	High
	Flowering time	36,13	0,63	High	4,55	12,60	Medium
	Fresh harvest time	48,38	0,91	High	5,97	12,35	Medium
	Number of pods per plant	49,35	0,82	High	38,52	78,06	High
	Pod weight per plant	329,51	0,81	High	267,03	81,04	High
CSGK	Pod length	13,59	0,47	Medium	1,00	7,34	Medium
	Pod diameter	1,03	0,66	High	0,12	11,32	Medium
	Pod weight	6,02	0,15	Low	0,22	3,62	Low
	Flowering time	32,56	0,41	Medium	2,36	7,24	Medium
	Fresh harvest time	45,52	0,86	High	5,21	11,45	Medium
	Number of pods per plant	26,73	0,69	High	15,98	59,77	High
	Pod weight per plant	160,77	0,03	Low	3,87	2,40	Low
CSM	Pod length	14,61	0,09	Low	0,15	1,05	Low
	Pod diameter	0,99	0,40	Medium	0,05	5,03	Low
	Pod weight	7,12	0,05	Low	0,08	1,18	Low
	Flowering time	34,95	0,51	High	2,94	8,41	Medium
	Fresh harvest time	47,61	0,85	High	4,43	9,31	Medium
	Number of pods per plant	24,29	0,51	High	9,37	38,57	High
	Pod weight per plant	173,91	0,08	Low	11,70	6,73	Medium
GKCS	Pod length	14,37	0,87	High	3,71	25,80	High
	Pod diameter	1,16	0,89	High	0,27	23,32	High
	Pod weight	7,23	0,71	High	1,83	25,33	High
	Flowering time	34,63	0,38	Medium	2,13	6,16	Low
	Fresh harvest time	47,16	0,90	High	6,32	13,40	Medium
	Number of pods per plant	32,63	0,74	High	18,65	57,15	High
	Pod weight per plant	242,73	0,64	High	147,51	60,77	High
MCS	Pod length	13,54	0,73	High	2,24	16,57	High
	Pod diameter	1,04	0,70	High	0,12	11,85	Medium
	Pod weight	6,12	0,28	Medium	0,53	8,62	Medium
	Flowering time	32,25	0,76	High	6,20	19,24	High
	Fresh harvest time	47,95	0,94	High	7,70	16,05	High
	Number of pods per plant	53,70	0,94	High	51,99	96,81	High
	Pod weight per plant	335,53	0,86	High	313,21	93,35	High

The Cherokee Sun x *Gogo Kuning* lines, for character that refers to the yield, such as weight of each pod and weight of pod per plant, has low genetic progress and heritability values, so that the selection would not be effective if it is done using this character. Character that supports the yield, which can be selected effectively in this line, is number of pods per plant because it has high genetic progress and heritability value. The increasing number of pods per plant, in general, could increase the yield in a line. The same thing has been experienced by Cherokee Sun x *Mantili* lines. *Gogo Kuning* x Cherokee Sun lines has high genetic progress and heritability value for almost all of the characters, except the flowering time and the fresh harvest time. Selection to increase the yield of this line could be done through characters of the pod length, weight of each pod, number of pods per plant, and weight of pods per plant. Character of the pod length in this line can be used as reference for selection because as a result of the questionnaires, the respondents prefer the yellow pod beans that having longer shapes. This selection could increase the pod length from 14 cm, on the average, to 18 cm. Character of the pod diameter could not be used in the selection criteria due to the beans have wider pod, and most of the customers dislike it. The same has occurred in *Mantili* x Cherokee Sun lines, which have high selection progress and heritability values, except for the pod diameter and weight of each pod. Selection to increase the yield of this line would be effective if it is done on characters of the pod length, number of pods per plant, fresh harvest time, and weight of pod per plant.

High heritability value plays very important role in increasing effectiveness of the selection. Character that having high heritability (table) for the selection, will go more effective due to small effect of the environment, so that the genetic factor would be more dominant in genetic appearance of the plant. On character for two low heritability values, the selection is relatively less effective due to the phenotype appearance of the plant is more affected by the environmental factor than the genetic factor.

High heritability enables it to follow selection in the next step. For instance, heritability value for number of pods per plant in Purple Queen x *Gilik Ijo* kines is 0.63. It means that 63% variance on character of the pod weight per plant has been affected by the genetic factor. The character can be improved for material of the breeding program in the future due to greater contribution of the genetic factor in the variance.

High heritability along with high expected genetic progress will increase the success of selection. This is conformed to opinions given by [7], in which the heritability would be more beneficial if it is guided by the phenotypic standard

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deviation and intensity of selection to find out the genetic progress or the selection response of a character.

Character that having high heritability value or above 0.5 shows that the genetic has the most dominant effect on plant F_2, while the environmental factor has less dominant effect. High heritability value has also caused by maximum segregation level on population F_2. Different background of the parental genetic between local and introduced varieties has also contributed high value of the heritability.

The selection progress can be used as guidance in determining the selection program. Greater progress means greater opportunities to improve the properties/ traits, but if the progress is insignificant, it means that the selection program should not be done due to the improvement is relatively low. However, integration between high heritability value and selection progress would assist in estimating the final result of the selection program.

4. Conclusion

1. Out of total 864 lines, 163 lines have been selected, which include 74 lines of purple pods and 89 lines of yellow pods. Results of the selection showed that 74 lines of purple pods derived from Purple Queen x *Gilik Ijo* for about 32 lines, Purple Queen x *Gogo Kuning* for about 20 lines, and Purple Queen x *Mantili* for about 22 lines. Results of the selection on 89 lines of the yellow pods derived from Cherokee Sun x *Gilik Ijo* for about 18 lines, Cherokee Sun x *Gogo Kuning* for about 15 lines, and Cherokee Sun x *Mantili* for about 20 lines, as well as *Gogo Kuning* x Cherokee Sun for about 30 lines, and *Mantili* x Cherokee Sun for about 6 lines.
2. The increasing yields of both purple and yellow pods for all lines are based on the genetic progress values, which will be more successful through character on number of pods per plant than character on weight of pod per plant.

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