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Agronomic characters and heritability of the third generation of Kampar mung bean lines (*Vigna radiata*)

DEWI INDRIYANI ROSLIM♥, TRESA NIA PRATIWI, HERMAN
Department of Biology, Faculty of Mathematics and Natural Sciences, University of Riau, Kampus Bina Widya, Jl. HR Soebrantas Km 12.5, Panam, Pekanbaru 28293, Riau, Indonesia. Tel. +62-761-63273, Fax. +62-761-63273. ♥email: dewiindriyaniroslim@gmail.com

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Abstract. *Roslim DI, Pratiwi TN, Herman. 2015. Agronomic characters and heritability of the third generation of Kampar mung bean lines (*Vigna radiata*). Nusantara Bioscience 7: 166-170.* Kampar district is one of the mung bean producing areas in Riau Province, Indonesia. The low productivity of Kampar mung beans can be enhanced by doing plant selection in each generation to yield an expected superior line. The research aims to determine the agronomic character and heritability of third generation of Kampar mung bean lines. This research was conducted from October to December 2014 in the experimental garden of Biology, Faculty of Mathematics and Natural Sciences, University of Riau, Pekanbaru, Indonesia. It used nine lines of mung beans and five replicates with the Completely Randomized Design as design of experiments. Agronomic characters observed included plant height, number of productive branches, flowering time, 90% of harvesting time, number of pods per plant, weight of pods per plant, number of seeds per pod, seed weight per plant, weight of 100 seeds, pod color, and seed luster, Analysis of data uses analysis of variance (ANOVA) and if further significant differences are found, Duncan's Multiple Range Test (DMRT) will be carried out. The results showed significant difference for all the characters studied. All agronomic characters observed showed high heritability values, ranging from 0.92 to 0.98. G3 lines produce the highest number of pods per plant and highest number of seeds per pod and have small-sized seeds. G5 line has heaviest weight of pods per plant and heaviest weight of seeds per plant and they are in the criteria for medium-sized seeds. G1 lines' seeds are classified as large seeds which are more superior to seeds of other lines. Therefore, lines of G1, G3, and G5 have the potential to be continued in the next generation because it is likely to contain potential sources of genes to get the superior Kampar lines mung bean.

Keywords: Agronomic characters, heritability, Kampar, lines, *Vigna radiata*

INTRODUCTION

Mung beans are a legume which has an important role in supporting the improvement of nutrition. Protein contained in mung beans seed is easier to digest (Butt and Batoola 2010) and low phytic acid than other legumes and cereals (Dahiya et al. 2015). The high availability of nutrients in mung beans plants make mung beans preferable by the public and is consumed to overcome anemia and as a nutritious food on the baby (Shanmugasundaram et al. 2009). Moreover, in terms of agronomy, mung beans plant could potentially become mainstay crop in the midst of extreme climate change and erratic, because it can be harvested earlier, or have earlier of time maturing (around 60 days) (Trustinah and Iswanto 2012) than rice or maize, it can improve soil fertility because of the capability of mung bean plants in fixing N, as well as it is relatively resistant to be grown in nutrient poor soils and dry climate (Lavanya et al. 2008; da Silva and Murdolelono 2012).

The centers of mung bean production in Indonesia are in Java, especially Central Java and East Java, and South Sulawesi. In 2014, the production level in Central Java is 31.942 tons, followed by South Sulawesi with 9.279 tons and 2.624 tons of East Java. But it is different from the condition in Riau Province; the level of production in 2014 is only 26 tons (Hardjo and Kadarmanto 2015). The low production of mung beans in Riau Province is caused by the width of cropland which is only 634 ha compared to the cropland in East Java province reaching 81.767 ha in 2014 (Hardjo and Kadarmanto 2014).

In addition to the harvesting area problem, the low production of mung beans in Riau Province is due to the using of local varieties of mung beans, i.e., Kampar varieties, by the farmers. Kampar district is mung beans production center in the province of Riau. The characteristics of Kampar mung beans are small grain, low production, asynchronous pods ripe, and the presence of trichomes in all parts of the plant. Although the trichomes is a means of plant to defense against pests (Weinhold 2012; Glas et al. 2012), but trichomes are very disturbing for farmers in harvesting mung beans because it can cause itching. The advantages of Kampar varieties is that it has adapted to the environmental conditions and to the climate of Riau province which is hot, and the soil is dry, acidic and poor in nutrient. One effort that can be done to increase the production of mung beans is repairing or assembling superior varieties of mung beans.

Research has been done to improve varieties of Kampar mung beans, namely by planting and picking certain plant number based on agronomic characters in each generation. At present, this has been done until the third generation. Therefore, in this study, the agronomic characteristic and

heritability of third generation of Kampar mung beans will be described.

MATERIALS AND METHODS

The plant material

The plant material is third generation of Kampar mung beans and its ancestor which is planted in the Garden of Biology, Faculty of Mathematics and Natural Sciences, University of Riau, Pekanbaru, Indonesia. The research was conducted from October to December 2014.

Research procedure

The design used in this research is completely randomized design (CRD) consisting of eight lines and one population of ancestors with 5 replications. A total of 25 mung beans grains of each line were grown in experimental plots with each measurement of 100 cm x 100 cm. Each plot was given by a mixture of manure and compost in the ratio 1: 1 (3 kg/plot: 3 kg/plot). Three weeks after that, the mung bean seeds were planted with drilling technique by ± 3 cm deep. The space among plants in the plot was 20 cm x 20 cm. The second fertilization was done when the plants were 2 weeks old and third was performed at 5 weeks after planting using NPK fertilizer as much as 125 grams/plot.

Plant maintenance included watering, weeding, and pest and disease control. Watering was done once a day in the morning, but when there was rain or the land was wet, the watering was postponed. Weeding was done in accordance with the conditions of the field. Pest and disease control was preventively done by keeping the test site clean and set spacing. When the pod skin was brown or black and became dried, the harvesting was carried out.

Observation parameter

Observation parameter includes: (i) Plants Height (cm). Plant height measurement was done by measuring plant from the base of the stem to the growing point of the plant. Measurements of plant height were carried out once, namely on the 50th days after planting. (ii) Number of productive branches per plant. The number of productive branches per plant was calculated at the time the plant was 50 days by counting the number of branches that produce flowers and pods. (iii) Flowering time (days). Flowering time was determined when the first flowers appeared on each plot. (iv) Harvesting time 90% (day). Harvesting time 90% was marked when 90% of plants in one plot have yielded ripe pods or pods were ready to harvest. The criterion for ripe pods was breakable black or brown pods skin. (v) The number of meaty pods per plant. Observations were made after the harvest. The calculated pods were the ones producing seed. (vi) The weight of pods per plant (g). Weight of pods per plant was determined by weighing all the pods from each plant at harvest. (vii) The number of seeds per pod. The number of seeds per pod was determined by counting the number of seeds per pod after harvesting. At each plant, 20 pods were taken randomly to count the number of seeds. (viii) The weight of seeds per plant (g). Seed weight per plant was determined by weighing the all grains of each plant. (ix) The weight of 100 grains (g). Weight of 100 grains was determined by weighing 100 mung bean grains from each plant. This measurement of 100 seeds was used to determine the size of the seed. Seeds were small, medium, and large. If the weight of 100 seeds ranges, respectively, ≤3,0 g, among 3-6 g, and ≥6 g (Musaddad 2005). (x) Pods color. Pod color was visually observed when the pods were ripe or on harvest time. (xi) Seed luster. Seed luster was observed after harvest. The luster of mung beans seeds was dull or shiny.

Data analysis

Data analysis was performed using analysis of variance (ANOVA). Based on F test, if between averages were significantly different at 5% level, then a further test, namely Duncan's Multiple Range Test (DMRT), could be carried out. Data were analyzed using SPSS 16. Also to be calculated was broad sense heritability value of each character with the following formula (Crowder 2010):

$$H = \frac{VG}{VP}; \quad VG = \frac{KTP - KTG}{Ulangan}; \quad VP = \frac{KTP}{Ulangan}$$

H is broad sense heritability value, VG is a genotype variation, VP is phenotype variation, KTP is treatment middle quadrate, and KTG is error middle quadrate. Heritability values are divided into three categories, namely low heritability if the value is less than 0.2, moderate heritability if the value lies between 0.2-0.5 and high heritability if the value is more than 0.5 (Stansfield 1991).

RESULTS AND DISCUSSION

Character of Kampar mung beans

The ANOVA result shows that 10 quantitative agronomic characters indicate a real difference among the 8 lines at $\alpha = 0.05$. Then, the 10 characters are further tested with DMRT and the result is shown in Table 1.

The vegetative character of plant height of nine lines of third generation of Kampar mung beans ranges from 62 to 96.5 cm (Table 1). The average height of the highest plants indicated by G3 line is 96.5 cm which has significant differences with other lines. The average height of the shortest plants indicated by G7 line is 62 cm which is also significantly different from the other lines. Whereas, on the second generation of local Kampar mung beans, an average height of the highest plant indicated by G6 lines is 61.2 cm and the shortest, also indicated by the G7 lines, is 43.6 cm (Herman et al. 2015). Average height of G0, G1, and G5 lines are not significantly different from G4 line and G4 lines are not significantly different from G2 line. G6 lines are significantly different from the line of G8 and G2 are also significantly different to seven other lines. Tall plants are expected to have high productivity because it has a lot of leaves, thus producing more photosynthate for the formation of flowers and seeds (Utami 2003).

Table 1. DRMT result of 8 lines (G1-G8) of third generation of Kampar mung beans and its ancestors (G0)

Lines	Plant height (cm)	Number of productive branches	Time of flowering (days)	Harvesting time 90% (days)	Number of pods per plant	Pods weight per plant (g)	Number of seeds per pod	Seeds weight per plant (g)	Weight of 100 seeds (g)	Pod color	Seed luster
G0	73.86^{d}	6.38^{a}	31.00^{a}	58.20^{a}	22.52^{ab}	21.98^{b}	11.30^{c}	14.64^{ab}	5.77^{d}	Black	Shiny
G1	73.70^{d}	6.66^{ab}	34.00^{bc}	58.20^{a}	27.56^{c}	27.28^{d}	11.00^{bc}	20.59^{d}	7.48^{e}	Black	Shiny
G2	68.38^{bc}	6.36^{a}	31.60^{a}	60.20^{bc}	24.92^{bc}	26.10^{cd}	10.95^{bc}	18.03^{c}	7.51^{e}	Black	Shiny
G3	96.50^{f}	10.18^{c}	39.00^{d}	61.20^{d}	49.02^{e}	26.28^{cd}	12.84^{e}	20.50^{d}	3.04^{a}	Black	Shiny
G4	72.46^{cd}	10.06^{c}	39.60^{d}	63.40^{e}	22.34^{ab}	22.14^{b}	11.69^{d}	14.85^{ab}	4.70^{bc}	Brown	Shiny
G5	73.16^{d}	6.74^{ab}	32.80^{ab}	59.80^{bc}	37.42^{d}	30.24^{e}	10.94^{bc}	22.05^{d}	5.17^{cd}	Blackish brown	Shiny
G6	81.44^{e}	6.68^{ab}	34.20^{c}	59.60^{b}	20.84^{a}	24.02^{bc}	12.64^{e}	16.67^{bc}	7.53^{e}	Black	Shiny
G7	62.00^{a}	6.56^{ab}	32.40^{ab}	60.20^{bc}	25.72^{bc}	19.00^{a}	10.65^{ab}	13.14^{a}	5.37^{cd}	Black	Shiny
G8	67.88^{b}	7.38^{b}	32.20^{ab}	60.40^{c}	27.80^{c}	17.78^{a}	10.39^{a}	12.58^{a}	4.17^{b}	Black	Shiny and dull

Note: The same letters in the same column showed no significantly different at $\alpha = 0.05$.

The character of productive branches number on the lines of third generation of Kampar mung beans ranges from 6.4 to 10.2 (Table 1). G3 and G4 lines have the highest number of productive branches while the G0 and G2 have the fewest number of productive branches. A large number of productive branches relates to the amount of interest and then affects the number of pods produced. This is supported by a statement of Herman et al. (2015) who said that if the number of productive branches on a plant is large, it will produce a lot of pods. Besides that, enough nutrients also influence the formation of the productive branches of the plant, due to the formation of a branch is through the process of cell division and enlargement.

The character of flowering time on third generation of Kampar mung bean lines ranges from 31-39 DAP (days after planting) (Table 1). Lines with the fastest time of emerging flower are G0 and G2 line i.e. 31-32 DAP, but they are not significantly different from the G5, G7 and G8 line. G4 and G3 line has the longest time for the flowers to bloom, namely at 39 DAP which is significantly different from other lines. In the previous study, lines of Kampar mung beans second generation had a flowering time of 31-33 DAP (Herman et al. 2015). A rapid flowering genotype is a genotype which is more early-ripening (*genjah*). On the other hand, a plant having a long vegetative period yields a longer period of flowering time, a taller plant, and produces a lot of leaves that provide higher productivity than that is produced by genotype with earlier flowering time (Utami 2003). Flowering time differences on each mung beans lines are suspected to be affected by genetic and environmental factors. According to Zebua et al. (2012) that changes in environmental and genetic differences lead to differences in the flowering of each plant.

The character of harvesting 90% on third generation of Kampar mung bean lines ranges from 58-63 DAP (Table 1). G0 and G1 lines have fastest harvesting 90% i.e. 58 DAP which is significantly different from seven other lines. Harvesting 90% in G6 line is significantly different from G8 line, but is not significantly different from G2, G5 and G7 lines. While the longest harvesting 90% is G4 line i.e. 63 DAP.

The period of pods ripening on these observed mung bean plants did not take place simultaneously, so, in this study, it required two crops to fulfill the purpose. According to Utami (2003) the longer the time of harvest, the more the number of pods formed thereby productivity is increased.

Number of pods per plant on Kampar mung bean lines third generation ranges from 20-49 pods per plant (Table 1). The highest average number of pods per plant is generated by G3 line, namely 49 pods, which is significantly different from eight other lines. G6 line has the fewest number of pods, that is 20.8 pods per plant and is significantly different from G2 and G7 line, but it is not significantly different from G0 and G4 line.

Mung bean genotypes with high pods yielding capacity produce more closely related to the weight of the pods (Mondal et al. 2011). But the weight of the pods do not depend on the number of pods will however depend on the level of kernel quality (Pratiwi et al. 2012).

Weight of pods per plant on Kampar mung bean lines third generation ranges from 17.8 to 30.2 g (Table 1). The heaviest weight of pods per plant is found in G5 line with 30.2 g which has a significant difference from other eight lines. G7 and G8 line has lightest weight of pods per plant and is significantly different from other seven lines. Meanwhile, the previous studies on Kampar mung beans second generation showed that the heaviest weight of pods per plant was produced by G6 lines, i.e. 18.9 g while the lightest weight of pods per plant was produced by G3 lines namely 10.8 g (Herman et al. 2015).

The number of seeds per pod on Kampar mung bean lines third generation ranges from 10.4 to 12.8 grains (Table 1). The greatest number of seeds per pod contained in G3 line, namely 12.8 seeds, but it is not significantly different from G6 line. G8 line produces the fewest number of seeds per pod, namely 10.4 grains, which is significantly different from the lines of G1, G2 and G5, but it is not significantly different from G7 line. Meanwhile, in previous studies, namely the study of purification of local lines of Kampar mung beans second generation, the highest number of seeds per pod was produced by G6 line, namely 15.4 seeds and the least number of seeds per pod was delivered by G7 and G8 lines (Herman et al. 2015).

Seed weight per plant of Kampar mung bean lines third generation ranges from 12.6 to 22 (Table 1). The heaviest average weight of seeds per plant is found in G5 line at 22 g which is not significantly different from G1 and G3 line.

G8 line has the lightest average seed weight i.e. 12.6 g which is significantly different from G6 line, but not with lines of G0, G4, and G7. According to Utami (2003) that the genotypes have long pods will produce larger grain size and is expected to have many seeds as compared to shorter-sized pods.

Weight of 100 seeds is an important character in the production of mung bean plants as it determines the size of the seed. The weight of 100 seeds in nine lines of Kampar mung beans third generation ranges from 3 g/100 seeds to 7.5 g/100 seeds (Table 1). According to Musaddad (2005), based on the weight of 100 seeds, seed size can be classified into three groups: small seeds (≤ 3.0 g/100 seeds), medium seeds (3.0/100 seeds-6.0 g/100 seeds), and large seeds (≥ 6.0 g/100 seeds). G1, G2, and G6 lines have the heaviest weight, namely 7.4 to 7.5 g/100 seeds and are significantly different from six other lines. All three are classified as large mung bean seed (Figure 1). Meanwhile, the group of medium-size seed consists of G0, G4, G5, G7 and G8 lines that have a weight range of 4.2 g/100 seeds-5.8 g/100 seeds. The lightest weight of 100 seeds is a G3 line, i.e. 3 g/100 seeds which belong to the criteria of small-sized seed and is significantly different from eight other lines. In the second generation, G3 line has small-sized seeds, G5, G7, and G8 lines have medium-sized seeds, G1, G2, G4 and G6 lines have large seeds (Herman et al. 2015).

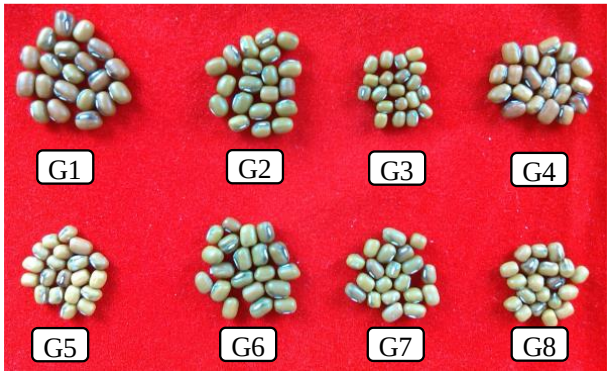

Figure 1. The size of Kampar mung beans in the third generation

The size of the grain size depends on the accumulation of carbohydrates of photosynthesis because the formation and development of seeds need a lot of carbohydrates (Zebua et al. 2012). Grain size determines the selling price and consumer tastes. Superior varieties of mung beans such as Nuri, Manyar, and Betet, despite high yield they have, they have small-size seed and dissatisfying quality so they are less attractive to farmers. On the other hand, local varieties of Demak and Belu having lower yielding and longer harvesting time, but they are still widely grown by farmers as they have larger seed, better grain quality, and the higher selling price than other varieties (Hakim 2009).

Ripe pods of Kampar mung bean third generation are black, which are found in G0, G1, G2, G3, G6, G7, and G8 lines. But the G4 line produces brown skin of pods, and G5 line produces blackish-brown skin pods (Figure 2).

In this study, nearly all lines have shiny seeds. Only G0 lines produce both shiny and dull seed. The large mung bean seed and dull green is preferred because it tastes better (fluffier) and suitable in cakes making (Hakim 2009). But consumers in India, Bangladesh, Pakistan, and Australia prefer shiny seed (Pal et al. 2010).

Heritability

The diversity of phenotypes seems to indicate whether a character is more influenced by environmental factors or by genetic factors. To determine the influence of environmental factors or genetic factors to a character, it can be seen from the value of heritability. The high broad sense heritability value shows greater genetic role than environmental factors (Alnopri 2004).

The results of study showed that the broad sense heritability for all characters is high, ranging from 0.92 to 0.98 (Table 2). The results showed that all nine agronomic characters examined were strongly influenced by genetic factors than by environmental factors. This was reflected in the real differences of each character among lines tested.

According to Trustinah and Iswanto (2012), if a character has a high heritability value, the properties will be easily passed on to the next offspring. Population of Kampar mung bean lines third generation have high heritability value and contains genes that control traits of important economic value, such as seed size, number of seeds per plant and the number of productive branches. Assembling these traits into a single plant can produce new varieties with high yield.

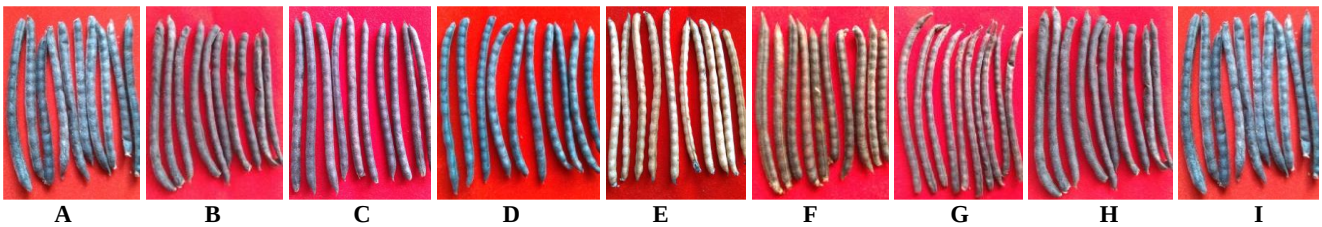

Figure 2. Skin pods color on 8 lines (G1-G8) of Kampar mung beans third generation along with their ancestors (G0). Note: A. GO (Black), B. G1 (Black), C. G2, (Black), D. G3 (Black), E. G4 (Brown), F. G5 (Blackish Brown), G. G6 (Black), H. G7 (Black), I. G8 (Black)

Table 2. Estimated value of broad sense heritability on the eight lines of Kampar mung beans third generation and their parents

Character	MQT	MQE	EV	TV	H
Plant height (cm)	4853.50	108.23	949.05	970.70	0.97
Number of productive branches	119.47	4.99	21.90	23.90	0.92
Flowering time (days)	48.96	1.89	9.41	9.80	0.96
Harvesting time 90% (days)	12.35	0.23	2.42	2.47	0.98
Number of pods per plant	4091.49	77.56	802.78	818.30	0.98
Pods weight per plant (g)	814.87	51.82	152.61	162.97	0.94
Number of seeds per pod	36.61	0.79	7.16	7.32	0.98
Seed weight per plant	603.20	32.48	114.14	120.64	0.95
Weight of 100 seeds (g)	12.86	0.36	2.50	2.57	0.97

Note: MQT = Middle Quadrate Treatment, MQE = Middle Quadrate Error, EV = Error Variation, TV = Treatment Variation, H = Heritability

In conclusion, G1 line is a line of large seed (7.5 g/100 seeds) having the fastest harvest time (58 days). G3 line produces the highest number of pods per plant (49 pods), the highest number of seeds per pod (12.8 seeds), and has small-sized seeds (3 g/100 seeds). While the G5 line has the heaviest weight of pods per plant (30.2 g), the highest weight of seeds per plant (22 g), and has medium-sized seeds (5.2 g/100 seeds). G1, G3, and G5 lines are lines that have the potential to be continued to the next generation because it is likely to contain potential sources of genes to get the superior Kampar mung bean lines. Heritability value on the ten agronomic characters studied is high. The high broad sense heritability shows genetic role is greater than environment role so the nine agronomic characters can be used as characters in selecting mung bean plants.

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