

Agronomic Characteristics and Nodules from Black Soybean Genotypes Due to Application Compost and Biochar as Sustainable Agriculture

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ABSTRACT

Purpose : Black soybean is a legume plant that has economic value on effective seeds and nodules, but out of the number of varieties that have been released until 2013 only 11 varieties are with agronomic height input innovation. The research objective is to obtain superior local genotype, as a source of new black soybean varieties, accompanied by compost and biochar-based agronomy practical innovations for sustainable agriculture.

Research Method : The first treatment was compost-based agronomy innovation with biochar (B): b_1 (1 t ha^{-1} + 1 t ha^{-1}) and b_2 : (1.5 t ha^{-1} + 0.5 t ha^{-1}). The second treatment was 4 genotypes of local black soybean (G): KB1, KA3, CK5, KH4, and as a comparison was a Cikuray variety with each treatment repeated three times. Anova test results of factorial patterns and DRMT Duncan's test at the 5% level.

Findings : Anova test results of factorial patterns and DRMT Duncan's test at the 5% level indicate that practical innovations based on compost and biochar agronomy accompanied by genotype have no effect. Both agronomy innovations b_1 and b_2 have the same effect on agronomic characters. Expected Genotypes that were superior to their agronomic character were shown by KH4 and KA3 genotypes with potential productivity of 3.28 t ha^{-1} and 3.19 t ha^{-1} , and increased by 21% and 17.71%, respectively. The genotypes of KB1, KA3 and KH4 produced the same number of nodules compared to Cikuray varieties.

Limitations : This research doesn't study about soil condition after the experiment.

Value : The novelty in this study is the use of low doses and directly applied to planting holes, obtained local genotypes superior agronomic characters for sources of new varieties, and obtained practical innovations based on compost and biochar agronomy for guidance for farmers who later selected regions as centers for varieties new black soybeans.

Keywords: compost, biochar, black soybean, agronomic characteristic, nodules

INTRODUCTION

Global warming has caused climate change, which encourages more frequent climate anomalies, such as El-Nino which causes drought or La-Nina which causes flooding. This situation is a challenge that needs to be sought a solution in the selection of new varieties of black soybeans, such as genotypes that are tolerant of climate change, drought, short-lived, disease-resistant, and widely adapted. Other advantages can be categorized at high yield levels over varieties that have been released (Menteri Pertanian RI. 2014 and

Balai Penelitian Tanaman Aneka Kacang dan Umbi. 2016), commercial values of the seeds such as antioxidant content, namely, dissolved phenolics (isoflavones and anthocyanins) (Kye

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Man Cho, *et al.*, 2013), levels of protein and carbohydrates, as a raw material for soy sauce and ingredients potential active for human health such as phenols, tannins and isoflavones (Debby, *et al.*, 2017), and oil content as a source of renewable fuels (Adi, *et al.*, 2014, Chindy, *et al.*, 2015, Ruvini, *et al.*, 2019).

KB1, KA3, KH4 and CK5 genotypes are local Indonesian soybean genotypes, a collection of plant breeding laboratories at the University of Padjadjaran, which is being continuously investigated. In 2013 the results of multi-location tests in 10 regions in Indonesia, including lowlands, medium and high, these four genotypes were revealed adaptive genotypes in the highlands, (Jatinangor area at an altitude of 780 m above sea level) and the results were higher than average results in 10 of these multi-location test areas (Chindy, *et al.*, 2015). Genotypes response is influenced by GEI (genotypes x Environment Interaction) or GGE (Genotype and genotype by environment Interaction). The significance value of GEI and GGE to the results shows that some genotypes are more stable in other environments (Ayda and Muchlish Adie, 2018; Yan., *et al.* 2000). Thus, the response of genotypes is used as a basis for the practical management of agronomy to choose suitable soybean development areas (Law and. James, 2011).

In the practical management of agronomy, low input agriculture innovations are needed, efficient, economical and applicable. Adding organic compost and biochar material to low organic soil is an effort to ameliorate the soil so that the application of plant nutrients can be more effective (Lehmann, 2007). In general, the provision of organic material will improve the physical, chemical, biological biology and yield of plants (Briljan, *et al.*, 2017; Gerard, *et al.*, 2018; Barrow, 2012; Lehmann, *et al.*, 2011) according to the characteristics of the genotype agronomics. Various forms of organic matter can be provided, depending on the availability at the farmer's level including sheep manure and rice husk for easy application. Application compost 25% and biochar 75% of (recommended dosage of compost 2 t ha⁻¹ and biochar 30 t ha⁻¹) can

increase the number of nodules per plant, the number of effective nodules, and soybean yield (Ruvini, *et al.*, 2019). Provision of biochar 5 t ha⁻¹ is not enough to increase the pH of Ultisol soils in the humid tropics. Biochar needs to be applied approximately every third season, similar to conventional liming, and the dose needs to be increased to 15 t ha⁻¹. The use of biochar is highly recommended for agricultural land in acid soils (Gerard, *et al.*, 2018).

The high dosage of the two ingredients was apparently not applicable and economical for farmers because of the height input of agriculture. From the calculation of the biochar rusk inventory, it turns out that 1 ha of paddy fields (yield of 5 t ha⁻¹) produces about 6 tons of organic material (straw) and 2 tons of husk per harvest, from the 50% organic material to compost 3 t ha⁻¹ and 1 ton ha⁻¹ to biochar rusk. Therefore, the novelty in this study is the use of low doses and directly applied to planting holes, obtained local genotypes superior agronomic characters for sources of new varieties, and obtained practical innovations based on compost and biochar agronomy for guidance for farmers who later selected regions as centers for varieties new black soybeans.

MATERIALS AND METHODS

The study was conducted in the experimental garden of the Faculty of Agriculture, University of Winaya Mukti, Indonesia, from May to August 2016 at an altitude of 850 m above sea level. The experiment was carried out by factorial randomized block design which was repeated three times. The first factor is the practical innovation of compost and biochar (B) based agronomies, namely: b₁ (1 t ha⁻¹ +1 t ha⁻¹) and b₂ (1.5 t ha⁻¹ + 0.5 t ha⁻¹). The second factor is the local genotype of black soybean (G), 4 genotypes, namely KA3, KB1, CK5, KH 4 and Cikuray varieties as a comparison. The ingredients consist of manure sheep's compost, biochar rice husk (which is burned in pyrolysis with temperatures around 300-400 ° C, urea fertilizer (45% N) 50 kg ha⁻¹, KCl (60% K₂O) 50 kg ha⁻¹ and SP36 (36% P₂O₅) 75 kg ha⁻¹.



Figure 01: Flowchart of research

Data were analyzed using ANOVA and DRMT/ Duncan's tests at the level of 5%. The experiment was carried out on moor fields with 125 cm x 200 cm plot size of 30 plots (one plot consisted of 25 plants). plants per treatment plot with a spacing of 25 cm x 40 cm. Compost and biochar applications are carried out when planting by mixing the two ingredients then put into the planting hole, then filled with 2 seeds. Application of N, P, K fertilizer is given from the age of 14 DAP/ Days. After Planting, Fertilizer N is given twice (each half dose at the age of 14 DAP and 35 DAP), Fertilizer P and K are given all doses at age 15 DAP. The measured parameters are the characteristics of growth, nodules, component yield and yields. The flowchart of research is shown in Figure 01.

RESULTS AND DISCUSSION

Result

Growth Phase

Supporting observations results (data not analyzed) of soil conditions before the study consisted of andisols, medium C-organic level (2.16%), medium N-total (0.30%), medium C/N ratio (12), medium P_2O_5 (35.00 mg 100 g⁻¹), high P available Bray 1 (14.00 mg kg⁻¹), low K₂O (18.00 mg 100 g⁻¹). The soil cation composition Na-dd (0.00054 cmol g⁻¹) is very low, Ca-dd (7.16 cmol g⁻¹) is medium, Mg-dd (2.12 cmol

g⁻¹) is high and K-dd (0.35 cmol g⁻¹) is low, CEC (37 cmol g⁻¹) is classified as high, low of pH (4.4 in KCl, 6.0 in water). Climatic conditions such as daily air temperature around 22-32°C, rain fall around 4.5-135.5 mm per month, humidity during the study around 60-80% per month and climate classification is rather wet (51.38%). Based on the environmental conditions, it turns out that the four genotypes of adaptive soybean plants live in this environment. Figure 02 indicates the results of observations of plant growth phases, for 4 local genotypes that have different phase ages compared to Cikuray varieties as a comparison.

Agronomics characteristic

Growth and nodules

The ANOVA and the DRMT Duncan's test level 5% statistical analysis results at the level of 5% indicate that the agronomy practical innovations based on compost and biochar (B) are: b_1 (1 t ha⁻¹ + 1 t ha⁻¹) and b_2 (1.5 t ha⁻¹ + 0.5 t ha⁻¹), with 4 genotypes (G) of KB1, CK3, KH4, and CK 5 as well as Cikuray as a comparison showed no influence on all measured agronomic parameters. The independent test results showed that agronomic practical innovations (B) had no significant effect, but the use of genotypes (G) showed an influence on agronomic traits, except shoot roots aged 14 DAP and 28 DAP and the weight of nodules per plant as shown in the Table 01.

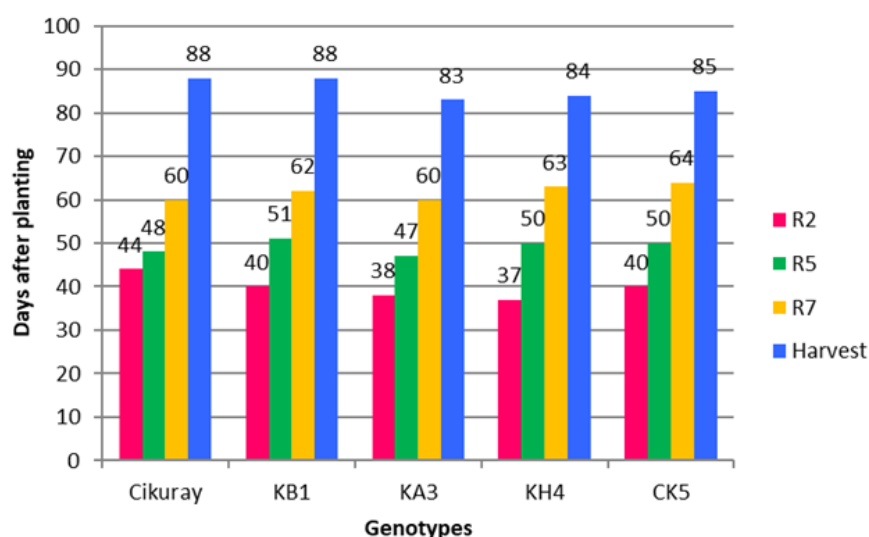


Figure 02: Phase R2 (Flowering), R5 (Pod filling), R7 (Mature) and Harvest of Black Soybean Genotypes

Table 01: Growth, nodules, components of yield and the productivity of black soybeans genotypes at different combinations of compost and biochar

Treatments	Growth						Nodules	
	Plant height (cm)			Shoot Root Ratio			Number Plant ⁻¹	Weights Plant ⁻¹
B	14 DAP	21 DAP	35 DAP	14 DAP	28 DAP	42 DAP	42 DAP	42 DAP
b ₁	11.964 a	21.17 a	46.20 a	2.44 a	2.10 a	3.90 a	25.67 a	0.41 a
b ₂	12.228 a	21.96 a	46.43 a	2.21 a	2.42 a	4.03 a	28.27 a	0.52 a
Genotip(G)								
Cikuray	15.43 d	27.82 d	53.94 c	2.53 a	2.28 a	5.40 d	32.17 b	0.41 a
KB 1	12.45 c	23.23 c	46.11 b	2.60 a	1.98 a	4.38 c	24.50 ab	0.52 a
KA 3	14.87 d	26.31 d	53.10 c	2.32 a	2.19 a	4.08 bc	33.00 b	0.41 a
KH 4	9.92 b	16.86 b	43.037 b	1.88 a	2.28 a	2.56 a	32.17 b	0.52 a
CK 5	7.91 a	13.62 a	35.38 a	2.29 a	2.55 a	3.42 b	13.00 a	0.41 a
	components of yield and the yields							
(B)	Number of pods plant ⁻¹	Number of seeds plant ⁻¹	Weight of seeds plant ⁻¹	100 seeds dry weight	Weight of Seeds plot ⁻¹	Yield t ha ⁻¹	Increase (%)	
b1	37.21 a	72.73 a	10.04 a	16.27 a	706.67 a	2.82	0	
b2	36.41 a	70.51 a	10.07 a	16.30 a	709.67 a	2.83	0.36	
Genotip(G)								
Cikuray	33.33 b	65.05 b	8.95 a	15.69 ab	677.50 abc	2.71	0	
KB 1	34.53 b	65.87 b	9.68 a	15.96 b	663.33 ab	2.65	-2.21	
KA 3	24.82 a	45.50 a	8.01 a	18.73 c	798.33 bc	3.19	17.71	
KH 4	24.82 a	64.15 b	9.50 a	17.83 bc	820.83 c	3.28	21.00	
CK 5	54.83 c	117.53 c	14.15 b	13.20 a	580.83 a	2.32	-14.39	

DAP/ Days After Planting. Followed by the same letter within each column were not significantly, different at the 5% level by DRMT Duncan,s test.

Yield components and the Yields

The ANOVA and the DRMT Duncan's test level 5% statistical analysis results at the level of 5% indicate that the agronomy practical innovations based on compost and biochar (B) are: b_1 ($1 \text{ t ha}^{-1} + 1 \text{ t ha}^{-1}$) and b_2 ($1.5 \text{ t ha}^{-1} + 0.5 \text{ t ha}^{-1}$), with 4 genotypes (G) of KB1, CK3, KH4, and CK 5 as well as Cikuray as a comparison showed no influence on all measured agronomic parameters. The independent test results showed that agronomic practical innovations (B) had no significant effect, but the use of genotypes (G) showed an influence on components of yield and the yields as shown in the Table 01.

In the Table 01: the CK5 could increase the productivity component such as the number of pods, number of seeds, and weight of seeds per plants. Along with the increase of 100 dry weight seeds quality, the weight of seeds per plot also increases the productivity (t ha^{-1}). The highest productivity was obtained by KH4 and CK3, potential productivity of 3.28 t ha^{-1} and 3.19 t ha^{-1} , respectively, and increase of 21% and 17.71% respectively. Thus, the genotype superior agronomic characteristics were KH4 and CK3, because they yielded a high productivity with a great seed of quality. This genotype is expected to be a source of new superior varieties at 850 m above sea level. With the same number of nodules as the Cikuray variety, it means that innovative agronomic practices based on compos and biochar can create an environment that is equally representative.

DISCUSSION

The growth in the Table 01: The plant height and shoot ratio of various genotypes at various ages show the diversity. Generally, the Cikuray variety shows the higher results compared to the 4 genotypes, and this is because the Cikuray variety has a broad adaptability and has been released by the government (Balai Penelitian Tanaman Aneka Kacang dan Umbi. 2016). There is no interaction of the measured agronomic character, possibly because composer and biochar (B) based agronomic practice innovations were firstly given into the

research area, so their effects on plants have not been significantly apparent in one planting season. Briljan, *et al.*, (2017), stated that to see an increase in soil properties and productivities requires a long time, biochar has the effect of neutralizing the pH which was initially slightly acidic to neutral, but to get a neutral pH on acidic soil requires repetition every third season with a dose of 15 t ha^{-1} . An application of B enhances C-organic so that there is an internal interaction between both of them in supporting a representative environment. Likewise, the response to the 4th genotype (G) on the two agronomic practices (B) innovation is more influenced by innate genes. Innate genes will dominate the phenotypic expression. Another possibility is that the given amount of biochar is too small, but the addition of biochar will reduce the crop productivity (Gerard, *et al.*, 2018)

The Nodules in the Table 01: It appears that the black soybean genotype produces the nodules that are the same number as the Cikuray variety (as a comparison variety), while the weight of nodules has no significant effect. This depends on the cooperation, presence and activity of rhizoid microorganisms that can tether N_2 in the air with its host plants. This is supported by (Lehmann, 2007; Sohi, *et al.* 2010) as stated that biochar has variable effects on soil microbes associated with plants and root nodulation by Rhizobia (generally increasing, due to efficient nitrogen fixation). Also, Iijim, *et al* (2015) states that biochar might be an artificial shelter for soybean nodule bacteria. The use of organic fertilizers can increase the number of nodules per plant: and the number of effective nodules due to combining compost 25% and biochar 75% of the compost dose (2 t ha^{-1}) and biochar 30 t ha^{-1} (Ruvini., *et al.* 2019). However, in this study the 4 genotypes were more dominant in expressing the same as Cikuray, and it was possible because environmental factors were in accordance with their needs (Couso and Fernandez. 2012).

In the Table 01: the CK5 could increase the productivity component such as number of pods, number of seeds, and weight of seeds per plants. Along with the increase of 100 dry weight seeds quality, the weight of seeds per

plot also increases the productivity ($t\ ha^{-1}$). The highest yields was obtained by KH4 and CK3, potential productivity of $3.28\ t\ ha^{-1}$ and $3.19\ t\ ha^{-1}$, respectively, and increase of 21% and 17.71% respectively. Thus, the genotype superior agronomic characteristics were KH4 and CK3, because they yielded a high productivity with a great seed of quality. This genotype is expected to be a source of new superior varieties at 850 m above sea level. With the same number of nodules as the Cikuray variety, it means that innovative agronomic practices based on compost and biochar can create an environment that is equally representative.

Khais, *et al* (2016), stated that the appearance of 16 genotypes of black soybean intercropped with maize, showed diversity in each genotype. This shows the stress of the influential environment. The ability of a genotype to environmental fluctuations is determined by its plasticity and phenotypic changes are triggered by variations in the dimensions of space and time.

CONCLUSIONS

Practical innovations based on compost and biochar based on genotype have no influence. The two agronomic innovations b_1 ($1\ t\ ha^{-1} + 1$

$t\ ha^{-1}$) and b_2 ($1.5\ t\ ha^{-1} + 0.5\ t\ ha^{-1}$), have the same effect on agronomic characters. Genotype expectation with superior agronomic character was shown by KH4 and KA3 genotypes with potential yield of $3.28\ t\ ha^{-1}$ and $3.19\ t\ ha^{-1}$, respectively, and increased by 21% and 17.70%. The genotypes of KB1, KA3 and KH4 produced the same number of nodules compared to Cikuray varieties.

Data Availability Statement

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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