eISSN: 1984-3909
Coffee Science, e202275, 2025

Doi: https://doi.org/10.25186/.v20i.2275

# The Influence of Robusta Coffee Grounds Proportion and Fermentation Time on The Quality of Bokashi

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Editor: Samuel Pereira de Carvalho
*Received in September 7, 2024 and approved in December 4, 2024*

## ABSTRACT

This research aimed to study the influence of robusta coffee grounds proportion as a mixture of raw materials for bokashi production and fermentation time on the quality of the bokashi. This research was conducted using a Completely Randomized Design with two factors and two replications. The first factor was the proportion of coffee grounds (A; 0, 10, 20, 30%), and the second was fermentation time (F; 0, 10, 20 days). Fish bone meal was added constantly to each sample as much as 5%. The analysis carried out on bokashi included microbial properties (total colony counts; TCC), temperature, chemical properties (pH value, water content, C, N, C/N ratio), descriptive organoleptic test (texture, colour, aroma), and plant growth test. The results showed that bokashi, with the addition of coffee grounds had better pH value, C content, and plant height, while worse in N content and C/N ratio. However, the C/N ratio value still met the standard (<20). There was no difference in pH, C, N, C/N ratio, and plant height among coffee grounds addition of 10% to 30%. The organoleptic characteristics of bokashi generally tend to be improved with fermentation time, although there was no difference among F2 and F3. The two best bokashi, namely A2F3 (10% coffee grounds and 20 days of fermentation) and A3F3 (20% coffee grounds and 20 days of fermentation) had similar characteristics, but A3F3 was the best since it had very significantly better plant height. The best experimental condition for the production of the bokashi was 20% coffee grounds proportion with 20 days of fermentation time.

**Key words:** Coffee waste; organic waste; biodecomposer; bokashi; C/N ratio.

## 1 INTRODUCTION

The need for organic fertilizer is increasing (Mardwita et al., 2019). This is due to the difficulty of access to chemical fertilizers, which are increasingly scarce and expensive for farmers. Apart from that, the awareness of the dangers of using chemical fertilizers on health is also increasing among the public (Siregar, 2023). As an alternative to replacing chemical fertilizers, farmers are starting to use organic fertilizers such as compost and bokashi (Wardani et al., 2023). Bokashi can improve the physical, chemical, and biological properties of soil (Makaruku; Wattimena, 2022; Holik et al., 2020). Agricultural products produced using bokashi are free from chemicals that are harmful to human health, so they are safer to consume (Tabun et al., 2017).

Bokashi is a mixture of various organic materials or waste that have been fermented by using a biodecomposer (Sadeli et al., 2022). Apart from helping reduce environmental pollution, waste utilization also increases the economic value of the waste (Andesta, 2020). Some organic waste that is often used in making bokashi include animal dung, bran, sawdust, and husk ash (Irfan et al., 2017a). Organic waste could give the best quality of compost or bokashi if the optimal process conditions were met, including the maintenance of C/N ratio (Zohra et al., 2022). A good quality bokashi that matches the soil C/N ratio range of 10–20 can be produced from organic raw materials with C/N of 30 to 70 within 10 days of fermentation as well as from raw materials with C/N of 110 after being fermented for 24 days (Irfan et al., 2024a).

Other organic waste can be added to the bokashi raw material mixture in a certain proportion, such as 20% green manure from *Soja hispida* and *Vigna sinensis* L. (Saygı, 2021). In other researches, 30% sago dregs and 5% fish bone meal were added and after 10 days of fermentation bokashi was produced with a TCC of $3.2 \times 10^8$ CFU/g and a C/N ratio of 13.8 (Irfan et al., 2016, Maridhi et al., 2020), 50% leaf waste, after 4 weeks of fermentation bokashi was produced with a TCC of $4.1 \times 10^8$ CFU/g and a C/N ratio of 10.2 (Irfan et al., 2022).

Gayo coffee pulp waste is also potentially added to the bokashi raw material mixture up to a proportion of 30% with 10 days fermentation time. This coffee bokashi has a TCC of $3.4 \times 10^8$ CFU/g and C/N ratio of 15.0 (Irfan et al., 2017b). Gayo Arabica coffee is generally produced in Central Aceh and Bener Meriah Regencies. Coffee pulp waste is produced in the upstream industry, namely in the process of processing coffee cherries into rice coffee. Meanwhile, in the downstream process, coffee grounds waste is produced from the process of brewing coffee drinks in coffee shops (Abubakar et al., 2023). The coffee bean process produces around 45% of waste in the form of coffee grounds. According to Purwaningtyas et al. (2022), every cup of coffee drunk usually contains around 20 grams of coffee grounds. Coffee grounds have great potential to provide some nutrients for plant growth (Putra et al., 2021). Coffee grounds contain 2.28% nitrogen and 0.6% potassium and a small amount of phosphorus, magnesium, and calcium which are useful for plant growth but with a low pH acid, namely 6.2 (Kondamudi, 2008). This research aimed to study the influence of robusta coffee grounds proportion as a mixture of raw materials for bokashi production and fermentation time on the quality of the bokashi.

## 2 MATERIAL AND METHODS

The materials used for bokashi production were cow dung, bran, husk ash, sawdust, coffee grounds, fish bone meal, and MOL(local microorganisms). Robusta coffee grounds were obtained from coffee shops around Banda Aceh City and Aceh Besar Regency. MOL was made using papaya and banana waste (Yunita et al., 2021). This research was conducted using a Completely Randomized Design with two factors and two replications. The first factor was the proportion of coffee grounds (A; 0, 10, 20, 30%). The second was fermentation time (F; 0, 10, 20 days). The number of the experimental unit with two replications amounted to 27 experiments. According to Murdikaningrum et al. (2023), coffee grounds are acidic, with a pH value of 5.6. Therefore, the use of coffee grounds must be accompanied by the addition of alkaline substances such as fish bone meal into the mixture. The data obtained was processed using Analysis of Variance (ANOVA). If there is a real effect on the treatment, then further analyzed by BNT Test.

### 2.1 Production of Microorganisms (MOL)

The portion of papaya and banana wastes (each 250 g), along with rice washing water (0.5 liters) and sugar (20 g) was crushed in a blender until homogeneous. This mixture was fermented in a closed container at room temperature for 7 days, resulting in MOL. MOL (2%) was used as a bioactivator or decomposer of organic in bokashi production (Yunita et al., 2021). According to Irna et al (2014), the addition of the MOL has an important role in bokashi production. MOL contains photosynthetic microbes, lactic acid bacteria, actinomycetes, fungi, and phosphate-solubilizing microbes which can accelerate the organic matter decomposition process.

### 2.2 Bokashi production

All organic waste/materials were mixed according to the formula in Table 1, adjusting for changes in the proportion of coffee grounds, along with 2% MOL, and mixed evenly. Water adequacy was identified easily through a handheld test. The characteristic of material with excessive water content was that the material would drip water when held. The mixture was then covered by a thick black plastic, with fermentation time according to the treatment. Turning was performed every 3 days so that the fermentation process was properly distributed. The analysis carried out on bokashi included microbial properties (total colony counts; TCC), temperature, and chemical properties (pH value, water content, C, N, C/N ratio) described by Irfan et al. (2016), while descriptive organoleptic test (texture, colour, aroma) followed Fauzan et al. (2022). C/N ratio is calculated from the ratio of the element C with Walkley and Black methods and N with Kjeldahl. For plant growth tests, corn seed Bonanza F1 was used following procedures Irfan et al. (2022).

**Table 1:** The formula of organic wastes/materials proportion in bokashi production.

| Organic Waste/Material | Formula (%)* | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Cow manure | 53 | 46.75 | 41.25 | 35.75 |
| Husk ash | 14 | 12.75 | 11.25 | 9.75 |
| Sawdust | 14 | 12.75 | 11.25 | 9.75 |
| Rice bran | 14 | 12.75 | 11.25 | 9.75 |
| Fish bone meal | 5 | 5 | 5 | 5 |
| Coffee Grounds | 0 | 10 | 20 | 30 |
| Total | 100 | 100 | 100 | 100 |

*Each formula is added with 2% MOL.

## 3 RESULTS

### 3.1 The Influence of Coffee Grounds Proportion

The influence of the proportion of coffee grounds on various parameters of bokashi quality is presented in Table 2. The proportion of coffee grounds had a very significant effect ($p \leq 0.01$) on the pH of bokashi and plant height, and significantly ($p \leq 0.05$) on C element, N element, and C/N ratio of bokashi. Presented in Table 2.

**Table 2:** The influence of coffee grounds proportion on the quality of bokashi.

| No | Quality Parameter | A1 (0%) | A2 (10%) | A3 (20%) | A4 (30%) | BNT |
|---|---|---|---|---|---|---|
| 1 | pH | $7.88^{b}$ | $7.34^{a}$ | $7.31^{a}$ | $7.28^{a}$ | $p \leq 0.01$ |
| 2 | C element (%) | $18.32^{b}$ | $14.38^{a}$ | $14.19^{a}$ | $13.84^{a}$ | $p \leq 0.05$ |
| 3 | N element (%) | $1.10^{b}$ | $0.75^{a}$ | $0.74^{a}$ | $0.70^{a}$ | $p \leq 0.05$ |
| 4 | C/N ratio | $16.65^{b}$ | $19.17^{a}$ | $19.18^{a}$ | $19.77^{a}$ | $p \leq 0.05$ |
| 5 | Plant height (cm) | $70.35^{b}$ | $74.17^{ab}$ | $83.58^{a}$ | $79.40^{a}$ | $p \leq 0.01$ |

### 3.2 The influence of Fermentation Time

The influence of the fermentation time on various parameters of bokasi quality is shown in Table 3. The fermentation time had a very significant effect ($p \leq 0.01$) on the TCC, temperature, texture, aroma, colour of pH of bokashi, and plant height.

### 3.3 The Influence of Interaction

The interaction proportion of coffee grounds treatment and fermentation time treatment (AF) had a very significant effect ($p \leq 0.01$) on the pH (Figure 1), texture of bokashi (Figure 2), and plant height (Figure 3).

**Table 3:** The influence t of fermentation time on the quality of bokashi.

| No | Quality Parameter | F1 (0 day) | F2 (10 days) | F3(20 days) | BNT |
|---|---|---|---|---|---|
| 1 | TCC (x $10^{8}$ CFU/g) | $7.6^{b}$ | $5.9^{a}$ | $4.8^{a}$ | $p \leq 0.01$ |
| 2 | Temperature ($^{o}$C) | $28.75^{b}$ | $33.63^{a}$ | $31.50^{a}$ | $p \leq 0.01$ |
| 3 | Texture (organoleptic) | $1.5^{b}$ | $4.0^{a}$ | $4.5^{a}$ | $p \leq 0.01$ |
| 4 | Colour (organoleptic) | $1.5^{b}$ | $3.6^{a}$ | $4.4^{a}$ | $p \leq 0.01$ |
| 5 | Aroma (organoleptic) | $2^{b}$ | $3.8^{ab}$ | $4.1^{a}$ | $p \leq 0.01$ |
| 6 | Plant height (cm) | $55.51^{a}$ | $79.54^{b}$ | $95.58^{c}$ | $p \leq 0.01$ |

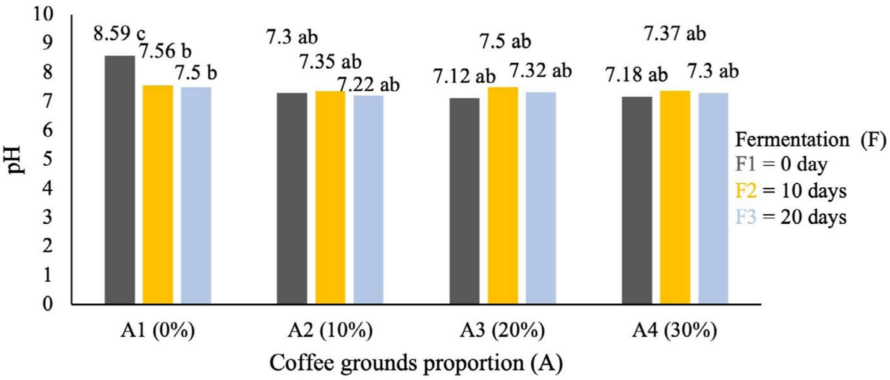


**Figure 1:** The influence of coffee grounds proportion and fermentation time (AF) on pH of bokashi (values followed by the same letter indicate no significant difference, $p \leq 0.01$, $BNT_{0.05}$= 0.52, KK= 2.29%).

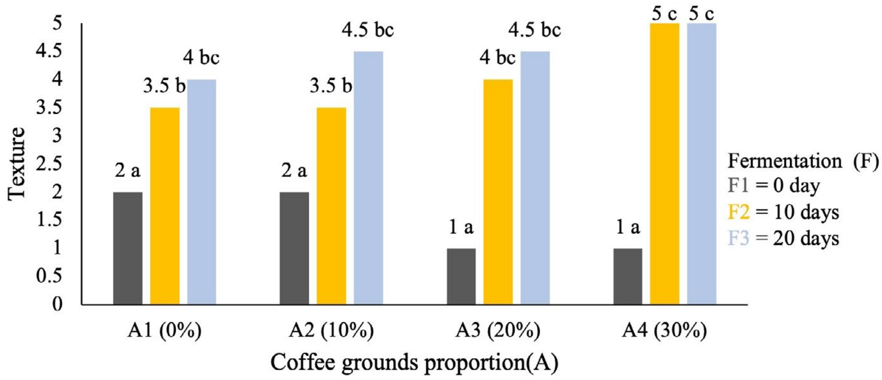


**Figure 2:** The influence of coffee grounds proportion and fermentation time (AF) on the texture of bokashi (values followed by the same letter indicate no significant difference, $p \leq 0.01$, $BNT_{0.01}$= 1.35, KK= 13.25%).

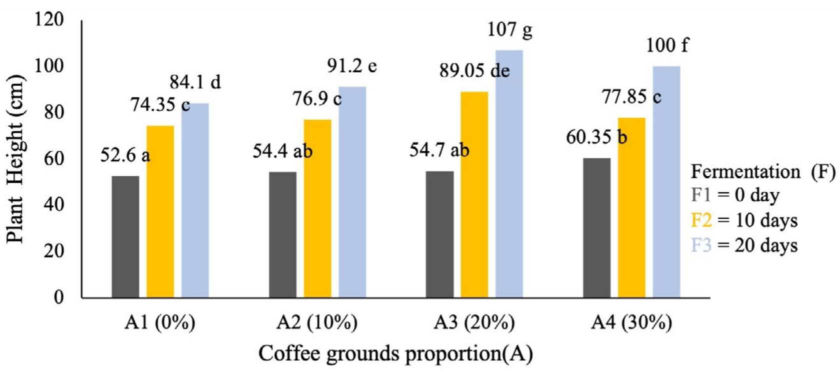


**Figure 3:** The influence of coffee grounds proportion and fermentation time (AF) on plant height (values followed by the same letter indicate no significant difference, $p \leq 0.01$, $BNT_{0.01}$= 6.08, KK= 2.59%)

## 4 DISCUSSION

### 4.1 Total microorganism of Bokashi

The total colony counts (TCC) of bokashi ranged from (4.4 – 8.6) x $10^8$ CFU/g with an average value of 6.1 x $10^8$ CFU/g. The amount of TCC in this research was not influenced by the proportion of coffee grounds but tended to decrease with increasing fermentation time (Table 3). The first result that TCC was not influenced by the proportion of coffee grounds was in line with Irfan et al. (2024b). The second result that TCC tended to decrease with increasing fermentation time was different from most other research on bokashi. TCC generally increases up to 10 days of fermentation, then decreases with increasing fermentation time depending on the availability of nutrients in the raw material. As the amount of nutrients decreases, this results in a decrease in the number of microorganisms in it (Irfan et al., 2016; Chinakwe et al., 2019). The rise and fall of TCC during bokashi fermentation are related to the availability and suitability of nutrients for the type of microorganisms that are developing (Irfan et al. 2017b). As TCC grows, energy in the form of heat is produced due to the activity of microorganisms in decomposing organic matter (Azim et al., 2018). Based on heat resistance, the microorganisms involved in the composting process are divided into mesophilic which work best at the temperature of 25°C-45°C and thermophilic microorganisms which work best at 45°C-85°C (Zohra et al., 2022; Biyada et al., 2021; Maccari et al., 2020). The bacterial CFU is higher than fungal CFU throughout the composting period for both mesophilic and thermophilic microorganisms (Chinakwe et al., 2019).

### 4.2 Temperature

The temperature of bokashi ranged from 28.50 – 34.50 ºC with an average value of 31.50 ºC. The data in Table 4 shows that the temperature without fermentation was lower and significantly different ($BNT_{0.01}$) compared to the bokashi temperature from 10 and 20 days of fermentation. The increase in temperature during fermentation was caused by the activity of microorganisms which decomposed organic materials with the presentation of oxygen-produced heat, $CO_2$, and water vapor as byproducts (Palaniveloo et al., 2020). After reaching its peak, the pile temperature then began to decrease because the activity of microorganisms that decomposed organic material decreased. This result was in line with the research of Makaruku and Wattimena (2022), where at the start of the composting process the bokashi experienced an increase in temperature from 30°C to 40°C, but then experienced a decrease on 13th day to a normal temperature of around 30°C. Turning can help to reduce overheating and facilitate better air circulation, including the release of $CO_2$ (Lamourou et al., 2023). According to El-mrini et al. (2022), a turning frequency of twice a week can produce a better quality of bokashi.

### 4.3 pH

The pH of bokashi ranged from 7.12 – 8.59 with an average of 7.45. The results of ANOVA showed that the proportion of coffee grounds (A) and the interaction of the two treatments (AF) had a very significant effect ($p \leq 0.01$) on the pH of bokashi. The results of the $BNT_{0.01}$ test (Table 2) showed that the pH of bokashi without coffee grounds addition (A1) was higher and significantly different from the others with coffee grounds addition, and there was no difference of pH among coffee grounds addition treatments (A2, A3, and A4).

In Figure 1 (AF interaction on pH) it can be seen that the highest pH was found at the A1F1 bokashi (0% coffee grounds and 0 days of fermentation), with a pH value of 8.59. This result was strengthened by the $BNT_{0.01}$ test which showed that the pH value of A1F1 bokasi was different from other treatment levels. In all of the bokashi samples, there was an additional 5% fish bone meal. According to Bunta, Naiu and Yusuf (2023), fish bone meal has a pH of 7.53 – 7.82. The high pH value of A1F1 bokashi was due to the addition of fish bone meal without any additional proportion of coffee grounds. In samples where coffee grounds were added, the pH of bokashi generally fell to near neutral pH. The recommended pH of bokashi to be used is 6.5−7.8. The pH of mature bokashi is close to neutral (Hutagalung; Rinaldi, 2019; Pan et al., 2012). Apart from A1F1, the bokashi pH in the results of this study was normal or good and met the bokashi pH quality standards.

### 4.4 Water Content

The water content of bokashi ranged from 42.37 – 62.25% with an average of 53.90%. The results of ANOVA showed that the treatment of A, F, and the interaction AF had no significant effect ($p > 0.05$) on bokasi water content. A water content range of 40% to 60% is considered optimal conditions for the metabolism of microorganisms. When the water content is below 40%, microorganism activity tends to decrease. Conversely, when the moisture content exceeds 60%, anaerobic conditions can occur, which can produce unpleasant odors.

### 4.5 C, N, and C/N Ratio

The carbon element of bokashi ranged from 11.70 – 19.89% with an average of 15.18%, nitrogen from 0.53 – 1.31% with an average of 0.82%, and C/N ratio from 14.62 – 24.87 with an average of 19.34. The results of the $BNT_{0.05}$ test (Table 2) showed that C and N of bokashi without coffee grounds addition (A1) were higher and significantly different from the others with coffee grounds addition, and there was no difference of C and N among coffee grounds addition treatments (A2, A3, and A4). The C element in the raw material was used as an energy source by the microorganisms where as nitrogen was an important component of cell structure (Kurniati et al., 2022). The decomposition process during fermentation causes carbohydrates, proteins, and fats to break down into simpler elements, and some of the C is released in the form of $CO_2$ (Irfan et al., 2017b; Palaniveloo et al., 2020) and N is released in the form of $N_2$ or $NH_3$ (Irfan et al., 2016). The C/N ratio of bokashi was also significantly ($P \leq 0.05$) influenced by the proportion of coffee grounds (A), however, based on $BNT_{0.05}$ test, there was no difference among A2, A3, and A4. Based on the Indonesian Standard, the C/N ratio of bokashi or compost (SNI-19-7030-2004) ranges from 10−20.

## 4.6 Organoleptic (Texture, Colour, Aroma)

Organoleptic tests were carried out descriptively on the texture, colour, and aroma of the bokashi. The category of descriptive value for the texture of bokashi (Irfan et al, 2016): 1. Very bad (raw/rough materials), 2. Not good (a little rude), 3. Ordinary (slightly loose), 4. Good (loose), and 5. Very good (loose, slightly moist). For Colour: 1. Very bad (raw material), 2. Not good (a bit like raw material). 3. Regular (slightly brown), 4. Good (dark brown), and 5. Very good (blackish). For Aroma: 1. Very bad (aroma of raw material), 2. Not good (slight raw material aroma), 3. Ordinary (slightly earthy), 4. Good (earthy aroma), and 5. Very good (strongly earthy aroma).

The texture of bokashi in this research ranged from 1 – 5 with an average of 3.3, colour from 1 – 5 with an average of 3.2, and aroma from 1.5 – 5 with an average of 3.2. As shown in Table 4, the organoleptic characteristics of bokashi generally tend to be improved with fermentation time, however, based on $BNT_{0.01}$ test there were no differences in texture, colour, and aroma among F2 and F3. Without fermentation (F1), the texture, color, and aroma of the mixture were still the same as the basic characteristics of the raw material. In F2 and F3, the colour and aroma of bokashi were dark brown and earthy aroma. These results were in line with Tallo and Sio (2019), that the longer the fermentation process, the more blackish-brown the color of the bokashi produced. The colour of the bokashi material changes gradually from light brown to brown, and finally at the final stage of the decomposition process, the colour changes to blackish brown. The longer the fermentation time, the better the color quality of the bokashi. Ripen bokashi is characterized by colour and aroma close to earthy (Nida et al., 2022; Niwati et al., 2021). The failed fermentation is characterized by a foul odor, and most likely an anaerobic decay process has occurred. This foul odor is caused by $H_2S$ gas, $NH_3$, and other volatile compounds (Kuroda et al., 2022; Lindamulla et al., 2022; Zhang et al., 2008). $CH_4$ gas is also produced in the anaerobic fermentation process, but this gas acts more as a greenhouse gas (Palaniveloo et al., 2020).

As shown in Figure 2 (the effect of AF interaction), the texture of bokashi tended to be improved with the increasing proportion of coffee grounds and the longer fermentation time. The highest texture values were in A4F2 (30% coffee grounds, 10 days of fermentation) and A4F3 (30% coffee grounds, 20 days of fermentation). The $BNT_{0.01}$ test results also showed that the texture of both bokashi was not different from that of A1F3, A2F3, A3F2, and A4F3. The texture is one of the indicators used to assess the quality of the bokashi, which is easy to observe. Good quality bokashi has a loose texture (Niwati et al., 2021). Changes in the texture of bokashi can be seen from the change in the basic material from hard to soft, resembling the texture of loose soil. When squeezed, good bokashi experiences a very clear change in shape and is no longer identified as the original base material. This change is caused by the activity of microorganisms during the fermentation process which decomposes the ingredients in raw materials so that the texture resulting from the decomposition process gradually changes (Makaruku; Wattimena, 2022).

## 4.7 Plant Height

The height of plants growing on bokashi at various levels of treatment ranged from 52.60 cm – 107.00 cm after 45 days, with an average of 76.88 cm. The results of ANOVA showed that the treatment of A, F, and the interaction AF had a very significant effect ($p \leq 0.01$) on plant height. The results of the $BNT_{0.01}$ test showed that the plant height was improved with the increase in fermentation time (Table 2). Regarding coffee ground proportion (Table 3), the plant height was better with the addition of coffee ground proportion, but based on $BNT_{0.01}$ test there was no difference among A2, A3, and A4 levels.

As shown in Figure 3 (the effect of AF interaction), the highest plant grew on A3F3 (20% coffee grounds and 20 days of fermentation) with a height of 107.00 cm, the second highest was A4F3 (30% coffee grounds and 20 days of fermentation) with a height of 100 cm and the lowest was A1F1 with a high of 52.60 cm (0% coffee grounds and no fermentation). The results of $BNT_{0.01}$ test showed that the plant height of A3F3 was significantly different from other levels. According to Fuadi et al. (2018), making bokashi using coffee grounds requires a longer fermentation time because most of the nutrients must change being absorbed by the plant.

## 5 CONCLUSIONS

Bokashi with coffee grounds proportion (A) had better quality characteristics in terms of pH closed to neutral, lower C content, and higher plant growth, on the other hand, lower quality in terms of lower N content and higher C/N ratio, but the C/N ratio value still met the standard. Bokashi with longer fermentation time tended to produce better organoleptic quality characteristics (texture, color, aroma) and plant height growth, although no differences were found between F2 and F3. The AF interaction had a very significant ($P \leq 0.01$) influence on pH, texture, and plant height. The two best bokashi, namely A2F3 (10% coffee grounds and 20 days of fermentation) and

A3F3 (20% coffee grounds and 20 days of fermentation) had similar characteristic, but A3F3 was the best since it had very significantly better plant height. The best experimental condition for the production of the bokashi was 20% coffee grounds proportion with 20 days of fermentation time.

## 6 ACKNOWLEDGEMENTS

The Department of Agricultural Product Technology at Universitas Syiah Kuala provided support for this study, for which the authors are grateful.

## 7 AUTHORS' CONTRIBUTION

Conceptual Idea: Sulaiman, I; Irfan, I ; Methodology design: Sulaiman, I; Irfan; Data collection: Sulaiman, I; Irfan, I; Fahmi,R; F; Fadhil, M, Data analysis and interpretation: Sulaiman, I,; Irfan, I and Writing and editing: Sulaiman, I; Irfan, I.

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