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THE EFFECT OF COFFEE PULP BOKASHI AND LOCAL MICROORGANISMS OF STALE RICE ON THE GROWTH OF ARABICA COFFEE (*COFFEA ARABICA* L) SEEDLINGS

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ABSTRACT

This study aims to determine the effect of coffee pulp bokashi and stale rice local microorganisms on the growth of Arabica coffee plant seedlings. This study used a factorial experiment, which tested two factors; namely bokashi coffee fruit skin in 5 dose levels, each: without treatment, 100 g/plant, 200 g/plant; 300 g/plant, and 400 g/plant; and local microorganisms of stale rice in 3 concentration levels, respectively: without treatment; 100 ml/L water; and 200 ml/L of water. The study results concluded that: Bokashi of coffee fruit skin at a dose of 400 g/plant had a good effect on plant height, the number of leaves, stem diameter, leaf area, root volume, plant dry weight, and net assimilation rate on arabica coffee plant seeds. Local microorganisms of stale rice with a concentration of 200 ml /L of water have a good effect on plant height, stem diameter, leaf area, number of leaves, plant dry weight, and net assimilation rate on arabica coffee seedlings. There was no interaction between the coffee fruit skin bokashi and stale rice local microorganisms on the coffee plant seeds.

Keywords*:* Arabica coffee plant seeds, coffee fruit skin bokashi, stale rice local microorganisms.

INTRODUCTION

Tana Toraja is known as a tourist destination and a producer of specialty coffee that the international community has recognized. Toraja specialty coffee, produced in the Tana Toraja Regency, North Toraja Regency, Enrekang Regency, and Mamasa Regency.

The production of coffee in Toraja has recently decreased drastically, from an average of 510 kg/ha per year in 2013 to an average of 370 kg/ha per year in 2020, thus far below the national production of 787 kg/ha/year (Tana Toraja Regency Agriculture Office, 2021)

Toraja Arabica coffee's low production is due to a combination of problems, including a lack of awareness of specialty coffee, ineffective farming techniques, uneven distribution of superior types, and poor post-harvest management.

Cultivation techniques include site selection according to growing requirements, seed and nursery selection, terrace construction and spacing arrangements, plant maintenance such as weeding, fertilizing, pruning, protective arrangements, pest and disease control.

Seedling is an early stage that determines the entire plant life cycle. One of the essential things in preparing seeds is a growing medium that prepares nutrients, water, and air for plants. Organic fertilizer is an integral part of the media because it is a source of nutrients and improves soil structure. Organic fertilizers are obtained from nature in agricultural waste, livestock waste, household waste, industrial waste, or particular plant parts processed into nutrients for plants.

Bokashi coffee husks are obtained by fermenting the skins of coffee cherries which were previously coffee plantation waste. Novita et al. (2018) analyzed wet-treated coffee fruit waste containing 1.86% Nitrogen, 0.16% Phosphorus, and 1.39% Potassium. The results of Puslitkoka's research (in Ramli et al., 2013) showed that levels of organic C-coffee pulp reached 45.3%, Nitrogen content was 2.98%, Phosphorus 0.18%, and Potassium 2.26%. The skin of the coffee fruit also contains elements of Calcium, Magnesium, Manganese, Ferrum, Cuprum, and Zeng. Those studies show that the bokashi of coffee pods can be used as fertilizer to meet the nutrient needs of plants.

Stale rice is a kitchen waste that has not been widely used as fertilizer. Stale rice contains 92 ppm Nitrogen (Sriyundiyati et al., 2013) and contains microorganisms (bacteria) that are useful for plants and soil fertility, such as Rhizobium sp, Azospirillum sp, Azotobacter sp, Pseudomonas sp, Bacillus sp (Rahayu and Tamtomo 2017).

Stale rice also contains local microorganisms, such as the bacterium Saccharomyces cereviceae, which can be employed as a liquid fertilizer or organic matter decomposer (Suyanto and Irianti, 2016).

The combination of treatment between bokashi of coffee fruit peel, which is a complete source of nutrients, with local microorganisms of stale rice, which is a source of nutrients, and a decomposer, is expected to accelerate the availability of nutrients for plants. Based on this description, the research problem was formulated as follows: "Does giving bokashi pulp coffee with different doses, and local microorganisms stale rice with different concentrations and the combination of the two give different effects on the growth of Arabica coffee seedlings?"

The study aimed to obtain the dose of bokashi fertilizer for coffee pods and the local microorganisms concentration of stale rice, which gave the best effect on the growth of Arabica coffee seedlings. The benefit of the research is to obtain the right combination of treatments to be applied to Arabica coffee nurseries. The study results are also expected to be a reference for further research.

RESEARCH METHODS

Study site

The research was conducted from April to November 2020 in the coffee plantation area of PT. Sulotco Jaya Abadi in Bolokan Lembang Tiroan, Bittuang District, Tana Toraja Regency. The research location is at an altitude of 1,400 m above sea level, with climate types A and B (Scmidt and Fergusson). The average rainfall in the area is about 3,000 mm/year. The average temperature is between 11 - 24 0C. The topography is sloping to mountainous with a soil pH of 5.3 – 6.2.

Research design

The study was carried out in a factorial experiment that tested 2 (two) treatments of arabica coffee plant seeds. The first treatment was bokashi fertilizer for coffee fruit pulp, consisting of 5 dose levels (g/tree) successively 0, 100, 200, 300, and 400. These are given symbols, respectively b0, b1, b2, b3, and b4. The second treatment was the local microorganisms concentration of stale rice, which consisted of 3 doses (ml/l water) 0, 100, and 200 respectively, which were symbolized m0, m1, and m2, respectively. Thus, there are 15 treatment combinations, namely: b0m0; b0m1; b0m2; b1m0; b1m1; b1m2; b2m0; b2m1; b2m3; b3m0; b3m1; b3m2; b4m0; b4m1; and b4m2. Each treatment combination was repeated 3 (three) times so that there were 45 experimental units, and in each experimental unit, there were six plants (seeds), so there were 270 plants in total.

The implementation of the research includes site preparation, making bokashi of coffee fruit peel and local microorganisms stale rice, preparing planting media (filling polybags), implementing treatment, planting seeds, maintaining, and observing. The plant parameters observed were plant height, number of leaves, stem diameter, leaf area, plant dry weight, root volume, net assimilation rate, and relative growth rate. Observational data for each observed variable was analyzed using variance (ANOVA), and if it had a significant effect, it would be continued with the 0.05 level BNJ test.

RESULTS AND DISCUSSION

Plant height

Analysis of variance showed that the bokashi treatment of coffee fruit peel and local microorganisms of stale rice significantly affected the average plant height. In contrast, the interaction had no significant effect. The results of the BNJ test (Table 1) showed that the bokashi treatment of coffee fruit peel at a dose of 400 g/plant gave the best effect (21.45 cm), the local microorganisms of stale rice at a concentration of 200 ml/l of water gave the best effect (19.45 cm). The interaction between the bokashi treatment of coffee fruit peel at a 400g/plant dose with local microorganisms of stale rice at a concentration of 100 ml/l of water resulted in the highest plant (22.31 cm).

Table 1. Average Plant Height at Age 16 weeks after plated (cm)

Treatments	m_0	m_1	m_2	Means	HSD (α 0.05)
b_0	16.9	17.03	17.39	16.90^a	
b_1	17.70	17.98	18.19	17.96^b	
b_2	18.51	18.81	19.11	18.81^c	0.50
b_3	19.58	19.90	20.26	19.91^d	
b_4	20.82	21,23	22.31	21.45^e	
Means	18.58^x	18.99^y	19.45^z		
HSD (α 0.05))		0.27			1.09

Note: The average value followed by the same letter in the row (a, b, c,…) and in the column (x, y, z) is not significantly different at the HSD test level of 0.05.

Table 2 Average Number of Leaves at the Age of 16 weeks after plated

Treatments	m_0	m_1	m_2	Means	HSD (α 0.05)
b_0	6.17	6.33	6.50	6.33^a	
b_1	6.67	7.00	7.17	6.94^b	
b_2	7.39	7.33	7.58	7.43^c	0.35
b_3	7.83	7.83	7.83	7.83^d	
b_4	8.00	8.08	8.17	8.08^d	
Means	7.21^x	7.31^{xy}	7.45^y		
HSD (α 0.05)		0.19			0.77

Note: The average value followed by the same letter in the row (a, b, c,…) and in the column (x, y, z) is not significantly different at the HSD test level of 0.05.

Number of Leaves

Analysis of variance showed that the bokashi treatment of coffee fruit peel had a very significant effect. The local organisms of stale rice significantly affected the average number of plant leaves, while the interaction had no significant effect. The results of the BNJ test (Table 2) showed that the bokashi treatment of coffee fruit peel at a dose of 300 g/plant gave the best effect (7.83 pieces), local microorganisms of stale rice at a concentration of 100 ml/l water gave the best effect (7.31 pieces). The combination of treatment between bokashi of coffee fruit peel at a dose of 400 g/plant with local microorganisms of stale rice at a concentration of 200 ml/l of water resulted in the highest number of leaves (8.13 leaves).

Leaf Area

Analysis of variance showed that the bokashi treatment of coffee fruit peel and local microorganisms of stale rice had a significant effect on the average leaf area. In contrast, the interaction had no significant effect. The results of the BNJ test (Table 4) showed that the bokashi treatment of coffee pods with a dose of 400 g/plant gave the best effect (152.11 cm2). The local microorganisms of stale rice with a 200 ml/l of water concentration gave the best effect (115.43 cm2). The combination of treatment with 400 g bokashi coffee fruit/plant skin with 200 ml/l local microorganisms water of stale rice resulted in the largest leaf area (162.87 cm2).

Root Volume

Analysis of variance showed that the bokashi treatment of coffee fruit peel had a significant effect on the average root volume. In contrast, the local microorganisms treatment of stale rice and its interactions had no significant effect. The results of the BNJ test (Table 6) showed that the bokashi treatment of coffee fruit peel at a dose of 400 g/plant gave the best effect (2.97 ml).

Table 4 Average Leaf Area at Age 16 weeks after plated (cm^2)

Treatments	m_0	m_1	m_2	Means	HSD (α 0.05)
b_0	58.92	67.25	77.92	68.03^a	
b_1	87.58	93.25	95.17	92.00^b	
b_2	98.83	104.08	109.25	104.06^c	10.32
b_3	109.92	115.00	132.67	119.19^d	
b_4	140.03	153.42	162.87	152.11^e	
Means	99.06^x	106.60^y	115.43^z		
HSD (α 0.05)		5.62			22.66

Note: The average value followed by the same letter in the row (a, b, c,…) and in the column (x, y, z) is not significantly different at the HSD test level of 0.05.

Table 6 Average Root Volume at Age 16 weeks after plated (ml)

Treatments	m_0	m_1	m_2	Means	HSD (α 0.05)
b_0	2.13	2.27	2.33	2.24^a	
b_1	2.13	2.30	2.33	2.26^a	
b_2	2.50	2.53	2.43	2.49^a	0.36
b_3	2.43	2.50	2.57	2.50^a	
b_4	2.73	3.07	3.10	2.97^b	
Means	2.39	2.53	2.55		
HSD (α 0.05)		0.20			0.80

Note: The average value followed by the same letter in the row (a, b, c,…) and in the column (x, y, z) is not significantly different at the HSD test level of 0.05.

Table 7 Average Net Assimilation Rate.

Treatments	m_0	m_1	m_2	Means	HSD (α 0.05)
b_0	0,36	0.44	0.49	0.43^{a}	
b_1	0.55	0.56	0.59	0.57^{ab}	
b_2	0.60	0.63	0.73	0.65^{bc}	0.21
b_3	0.79	0.85	0.87	0.84^{c}	
b_4	0.93	1.12	1.26	1.10^{d}	
Means	0.65^{x}	0.72^{xy}	0.79^{y}		
HSD (α 0.05)		0.11			0.45

Note: The average value followed by the same letter in the row (a, b, c,…) and in the column (x, y, z) is not significantly different at the HSD test level of 0.05.

Net Assimilation Rate

Analysis of variance showed that the bokashi treatment of coffee pods had a very significant effect. The local microorganisms of stale rice had a significant effect, while the interaction had no significant effect on the average net assimilation rate. The results of the BNJ test (Table 7) showed that the bokashi treatment of coffee pods with a dose of 400 g/plant gave the best effect (1.10), local microorganisms of stale rice with a concentration of 100 ml/l of water gave the best effect (0.72). The combination of treatment with 400 g of bokashi coffee fruit/plant skin with 200 ml/l local microorganisms of stale rice resulted in the highest net assimilation rate (1,26).

Relative Growth Rate

Analysis of variance showed that the bokashi treatment of coffee cherries had no significant effect on the relative growth rate.

Bokashi Coffee Pulp

The analysis of variance showed that the administration of bokashi pulp of coffee at various doses gave significantly different effects on all observed growth components except the relative growth rate. The results of the 0.05 BNJ test showed that the 400 g/tree treatment gave the best effect on plant height, number of leaves, stem diameter, leaf area, plant dry weight, root volume, and net assimilation rate. It is suspected that in the treatment with a 400 g/tree dose, sufficient nutrients were available to meet the needs of coffee plant seeds. The content of elements in the coffee fruit skin is: 2.98% nitrogen, 0.18% phosphorus, 2.26% potassium, as well as elements, Ca, Mg, Mn, Fe, CU, and Zn (Melisa, 2018), which although small amount but is needed by plants in their growth. Meanwhile, the Directorate General of Plantations (in Melisa, 2018) presented the results of the analysis, which showed a higher nitrogen content (4.73%), as well as phosphorus (0.21%) and potassium (2.87%) far exceeding the SNI requirements for compost. namely N 0.40%, P 0.10%, and K 0.20% (BSN, 2004). This shows that the bokashi of coffee fruit skin, in terms of its elemental content, is suitable for use in farming.

The nitrogen in the bokashi of coffee cherries functions to stimulate overall plant growth, primarily stems, branches, and leaves, and plays an essential role in the formation of green leaves, which are very useful in photosynthesis. Nitrogen also functions to form proteins, fats, and various other organic compounds. Phosphor stimulates the formation of roots, especially seeds and young plants, as a raw material for forming specific proteins, helps assimilation and respiration, and accelerates flowering, seed formation, and fruit ripening. Potassium helps the formation of protein and carbohydrates, strengthens the plant body so that leaves, flowers, and fruit do not fall easily, increases plant resistance to drought and disease, and improves the quality of seeds/fruits. Rosmarkam and Yuwono (in Haryadi et al., 2015) asserted that plants that received an adequate supply of N would be stimulated by vegetative growth, including increasing plant height, greener plants because they contain lots of chlorophyll, and increasing protein and fat content.

Nitrogen also plays a role in the formation of chlorophyll, which determines the process of photosynthesis. Plant chlorophyll is composed of atoms of Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), Magnesium (Mg), and iron (Fe), as well as microelements such as Manganese (Mn), Cuprum (Cu) and Zeng (Zn) which are needed in small amounts. However, if they are not present, the plant will experience chlorosis and inhibit the photosynthesis process. In photosynthesis, chlorophyll functions to utilize solar energy triggers the fixation of CO2 into carbohydrates and provides an energetic basis for the ecosystem.

The subsequent growth factor is the increase in the volume of protoplasm, which is influenced by the availability of carbohydrates, absorption of water and nutrients, the movement of nutrients and water in plants, the preparation and overhaul of proteins, fats, and other inorganic substances (metabolism), and the formation of energy through the respiration process. This shows that the increase in the volume of protoplasm is highly dependent on the availability of elements, especially nitrogen. In line with Arimbawa (2016) stated that growth is the result of the interaction between internal and external factors of the plant. Internal factors include genetic factors (heredity), enzymes, and growth regulators (hormones), while external factors include: temperature, sunlight, rainfall, altitude, soil, water, and elements.

The increase in plant height results from cell division in the primary meristem. The availability of sufficient nutrients in the bokashi of coffee pods and the creation of a loose soil structure will stimulate stem growth, which will trigger the increase in plant height. The higher the dose of bokashi given will also increase the content of P and K elements in the soil.

In addition to stimulating the generative portions of plants (flowers, fruit, and seeds), Phosphorus also promotes root growth and wider root dispersion, improving water and nutrient absorption, and encouraging the growth of plant tissue, particularly at the developing points of plants.

Meanwhile, potassium acts as an enzyme activator, helps absorb water and nutrients, helps transport assimilated products to all plant tissues, plays a role in maintaining plant balance, and strengthens tissue so that plants stand strong, healthy, and have resistant to pests and diseases.

Besides growth in primary meristems, cell division also affects secondary growth in cambium formation, which encourages stem enlargement (diameter). Potassium contained in the bokashi of coffee pulp plays a role in increasing tissue volume and strengthening the stem. Menas (2010) suggested that potassium helps the formation of protein and carbohydrates, which play a role in strengthening the plant body hardening straw and woody parts of plants.

Plants that get an adequate supply of N elements will have better vegetative growth, indicated by the greener leaf color of the plant because it contains much chlorophyll, so it has the potential to increase the size (area) of the leaves. The higher the dose of the bokashi skin of the coffee fruit given, the better the effect on the leaf area. The increase in leaf area is an essential part of plant growth. According to Gomies et al. (2012), the increase in leaf area is an effort by plants to streamline the capture of sunlight energy for photosynthesis, typically even in conditions of low light intensity. Thus, the addition of leaf area provides an overview of the process and rate of photosynthesis. Ramli et al. (2013) added that the leaf area largely determines the ability of plants to carry out photosynthesis, where the more prominent the leaf area, the greater the light that the plant can capture.

Another indicator of ongoing plant growth is the increase in plant dry weight. The process of photosynthesis that occurs in the leaves produces photosynthate, which is then translocated to plant parts such as stems, roots, and leaves. Suryaningrum et al. (2016) stated that plant dry weight reflects the accumulation of organic compounds that plants have successfully synthesized from inorganic compounds, especially water and carbon dioxide. Nutrients that roots have absorbed contribute to the increase in plant dry weight.

Phosphorus and potassium elements in coffee husk bokashi play a role in stimulating the formation of the roots of coffee plant seeds. In addition, bokashi plays a role in forming a loose soil structure and has high porosity so that it is easy for roots to penetrate and has good drainage and aeration. The higher the dose of the bokashi pulp of coffee given, the faster root development, so that the root volume increases. Sutejo and Kartasasmita (in Ramli et al., 2013) emphasize that the development of plant roots requires N and P elements which are part of the protoplasm and cell nucleus. Perfect root development will optimize the absorption of water and nutrients.

The net assimilation rate showed high photosynthetic efficiency, indicating good leaf growth and chlorophyll content. The net assimilation rate is associated with leaf area and dry matter produced from a certain period (Saragih, 2019). The inhibition of leaf expansion will impact decreasing the capacity of the leaves to absorb light.

Local microorganisms of Stale Rice

The analysis of variance showed that giving local microorganisms with different concentrations gave different effects on the observed growth components except for root volume and relative growth rate. The results of the BNJ 0.05 test showed that a concentration of 200 ml/l water had a good effect on plant height, stem diameter, and leaf area, which were significantly different from other treatments. In contrast, the effect was not significant on the number of leaves, plant dry weight, and net assimilation rate compared to 100 ml/l water treatment, but significantly different from no treatment.

Stale rice contains several essential nutrients, including carbohydrates, protein, minerals such as iron (Fe), phosphorus (P), manganese (Mn), selenium, magnesium (Mg), potassium, and some vitamins. Local microorganisms solution of stale rice contains micro and macronutrients. Also, it contains bacteria useful for liquid organic fertilizer, decomposers or compost for composting, and organic pesticides to control pests and plant diseases. Local microorganisms also contains growth hormones such as gibberellins, cytokinins, and auxins, which function as plant growth stimulants. According to Julita et al. (2013), the stale rice contained Azotobacter bacteria, beneficial for organic decomposition matter.

Azotobacter, according to Rahmi (2014), is a plant growth-promoting rhizobacteria (PGPR). As a biological fertilizer, Azotobacter plays a role in increasing plant productivity. These bacteria can produce vitamins and growth regulators such as IAA, kinetin, and gibberellins, accelerating seed germination. In addition, Azotobacter can fix nitrogen non-symbiotically, increase phosphorus availability, and produce extracellular polysaccharides, such as alginates and polymers.

Local microorganisms of stale rice containing Azotobacteria as PGPR, besides being friendly to the environment and improving soil quality, also stimulates plant growth by facilitating the acquisition of nitrogen, phosphorus, and other essential minerals, increasing the absorption of cytokinin and auxin hormones by plants (Hindersah et al., 2018). The increase in plant height, stem diameter, leaf area, number of leaves, plant dry weight, and net assimilation rate was thought to increase soil nitrogen content by giving local microorganisms of stale rice.

Stale rice contains 0.7% N nutrients; P205 0.4%; K20 0.25%, organic matter 21%, Ca0 0.4% and the ratio CN 20-25 (Purwanto, et al., 2018). The availability of N as a component of chlorophyll formation increases the photosynthetic process that stimulates plant growth, such as increasing plant height, stem diameter, number and area of leaves, and net assimilation rate. In comparison, phosphorus is an essential component of ADP and ATP, which increase the process of photosynthesis and absorption of ions that are useful in increasing the number and size of leaves. Potassium plays a greater role in the formation and translocation of carbohydrates to other plant parts. It activates enzymes that trigger photosynthesis, which increases plant tissue and subsequently plant dry weight.

Interaction of Bokashi Fruit Skin Coffee with Local Microorganisms Stale Rice

The analysis of variance showed that the combination of bokashi treatment with coffee pods with local microorganisms of stale rice had no significant effect on plant growth components observed at the age of 16 weeks after being planted. The results of the BNJ 0.05 test showed that the combination of bokashi treatment with coffee pulp at a dose of 400 g/plant and local microorganisms of stale rice at a concentration of 200 ml/liter of water gave the highest yield but was not significantly different from other treatments. There was no interaction between this treatment, presumably because the coffee pulp used in the experiment was previously fermented with the help of EM4 bio activator. Thus the skin of the coffee fruit has been decomposed to be ready for use by coffee plant seeds, so the role of stale rice local microorganisms as a decomposer and PGPR, which supplies N, is not fundamental.

CONCLUSION

1. Bokashi coffee fruit pulp at a 400 g/tree dose had a good effect on plant height, number of leaves, stem diameter, leaf area, root volume, plant dry weight, and net assimilation rate on the growth of Arabica coffee seedlings.
2. Local microorganisms of stale rice with a concentration of 200 ml/litre of water had a good effect on plant height, stem diameter, leaf area, number of leaves, plant dry weight, and net assimilation rate on the growth of arabica coffee seedlings.
3. There was no interaction between the bokashi of coffee fruit peel and local microorganism of stale rice on the growth of coffee plant seeds.

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