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Elevating the Growth and Production of Asparagus Beans Through the Use of Coffee Grounds and Rice Husk Ash

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Abstract

Asparagus beans (*Vigna unguiculata* subsp. *Sesquipedalis*) have high economic and nutritional potential, but their yield has declined due to suboptimal land fertility. Inorganic fertilizers pose adverse influence on the environment, so more eco-friendly organic materials, such as coffee grounds and rice husk ash are necessary. This study aims to evaluate the effect of coffee grounds and rice husk ash on the growth and production of asparagus beans. It was conducted in the experimental garden of the Faculty of Agriculture, Universitas Borneo, Tarakan City, using a Randomized Block Design (RBD) with five treatments: no coffee grounds and rice husk ash (P0), 1.5 ton/ha of coffee grounds (P1), 4 ton/ha of rice husk ash (P2), 0.75 ton/ha of coffee grounds + 2.0 ton/ha of rice husk ash (P3), and 1.5 ton/ha of coffee grounds + 4 ton/ha of rice husk ash (P4). The results corroborated that using 1.5 ton/ha of coffee grounds (P1) yields the highest outcome with respect to plant height (113.4 cm), the number of leaves (38 strands), the number of pods to the control (4 pieces), the length of the pods (4.01 cm), and the weight of the pods (140.65 g), compared to other treatments and control. Coffee grounds are proven a more effective material than its combination with rice husk ash in elevating the growth and yield of asparagus beans in red-yellow podzolic soil.

Keywords: Asparagus beans, coffee grounds, growth, production, rice husk.

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INTRODUCTION

Asparagus beans (*Vigna unguiculata* subsp. *Sesquipedalis*) possess substantial potential for economic advantage. There are also important in improving community nutrition, due to the abundance of carbohydrates (23.6%), protein (24.4%) and fat (44.2%) (Ramdani *et al*., 2019). Asparagus beans are known as one of the versatile vegetables which can be served in various menus. Fresh asparagus beans are commonly used as a side dish served with chilli sauce, or as a mixture of salads and *pecel* (peanut sauce), offering a distinctive crunchy and fresh taste. In addition, asparagus beans can be processed into stir-fried asparagus beans, *lodeh* (a coconut milk-based vegetable soup), or a mixture of *oseng-oseng* with a tempting flavour. This flexibility makes asparagus beans a favourite choice to satisfy daily nutritional needs.

Asparagus beans are one of the well-known agricultural commodities in Tarakan City. In 2023, the Central Statistics Agency (*BPS*) of North Kalimantan Province reported that asparagus bean production in Tarakan City reached 13,820 quintals, despite production fluctuations across the years. Data analysis from 2016 to 2020 marked volatile amount of production, apparently influenced by weather conditions, cultivation techniques, and availability of agricultural land. Stable weather with sufficient sunlight is highly crucial to support optimal growth of asparagus beans because this plant requires a warm climate and moderate rainfall (Ayu *et al*., 2021). In addition, proper cultivation techniques, such as selecting superior seeds, good soil cultivation, and pest and disease management, play a big part in harvest success (Sandhu *et al*., 2021). Another driving factor is the availability of agricultural land (Reij & Smaling, 2008). Fertile and adequate land allows farmers to cultivate asparagus beans optimally. These three factors, when managed properly, contribute to elevating asparagus bean productivity, making them essential measures to meet market needs and provide economic gains for farmers. Notwithstanding, plant cultivation in Tarakan City is generally obstructed by the Red Yellow Podzolic (RYP) soil which is classified as marginal soil with physical or chemical conditions that can drastically reduce plant growth (Pradana *et al*., 2022). This soil often has suboptimal fertility, moisture, pH, or nutrient levels. RYP is one soil type prevalent in tropical areas, including in Indonesia. It is formed through an intensive weathering process under wet conditions with high rainfall (Andriesse, 1969). Due to the long weathering process and leaching of nutrients, this soil requires sophisticated management.

Physically, this soil is generally dominated by clay fractions. This characteristic causes this soil to possess a fairly decent water retention capacity, but can also result in poor drainage under particular conditions. The soil structure is often massive, which means that soil particles tend to stick together, establishing a hard mass that is difficult to process. Another problem with the soil is its high bulk density, leading to low soil porosity. This inhibits the movement of air and water, therefore impacting root growth. In addition, the soil has quite serious erosion problems due to unstable soil aggregation (Prasetyo & Suriadikarta, 2006).

From a biological viewpoint, the RYP soil has low soil microorganism activity due to the limited organic matter resulting from the rapid decomposition in tropical environments. Low organic matter can bring down the population of soil microorganisms, such as phosphate-solubilizing bacteria and arbuscular mycorrhizal fungi. These play an important role in the soil nutrient cycle. In addition, soil fauna, such as earthworms that help form soil structure and increase porosity, is found in small numbers in RYP soil. This low biological activity affects soil's natural ability and overall quality (Supriyadi *et al*., 2021).

The chemical properties of RYP soil are characterized by low fertility levels. One of its main characteristics is the soil pH, ranging from 4 to 5. High soil acidity is influenced by a substantial content of Al (aluminium) and Fe (iron), which are toxic to plants. This soil also has a low cation exchange capacity (CEC), subsequently limiting its ability to store and provide nutrients for plants. The availability of macronutrients, such as nitrogen (N), phosphorus (P), and potassium (K), in RYP soil is also very limited. Phosphorus is often bound by Al and Fe so it is hardly available for absorption by plants. Likewise, micronutrients, such as boron (B) and zinc (Zn), are also deficient (Baligar *et al*., 2004).

In Indonesia, the management of RYP is particularly significant due to the country's reliance on agriculture as a primary economic sector. Crops such as rice, maize, and oil palm are often cultivated on RYP soils. Research and extension services provided by institutions such as Indonesia's Ministry of Agriculture and local universities play a crucial role in disseminating knowledge about sustainable soil management practices to farmers. The importance of sustainable management of RYP is underscored by its role in food security and environmental conservation. Without proper management, the degradation of RYP can lead to reduced agricultural productivity, threatening livelihoods and exacerbating land-use pressures in tropical regions. Thus, ongoing research and the development of innovative soil management techniques remain vital to ensure the sustainable use of this soil type for present and future generations.

Maintaining the stability of commodity production is inseparable from the role of inputs such as fertilizers. Using fertilizers with the right dosage can be one apt measure to address the issue. Careful moderation in the use of fertilizer in alignment with plant needs can result in optimal nutrition, optimal growth, and improved production (Majumdar *et al*., 2013). Farmers need to understand the type of suitable fertilizer and the right dosage for each type of plant. Not only such a measure elevates soil fertility, but it will also contribute to enhanced farmer welfare and sustained food security.

Inorganic fertilizers have been widely used in cultivating asparagus beans in Tarakan City. Farmers often rely on various inorganic fertilizers to attain optimal plant growth and abundant harvests. This is consistent with the views of Rychter *et al*. (2016), Lestari *et al*. (2021), Rawat *et al*. (2016) and Zenda *et al*. (2021) who assert that inorganic fertilizers contribute significantly to plant growth and yield. Despite supporting plant growth and production, inorganic fertilizers adversely affect the environment, as they bring down the organic matter in the soil, damage soil structure, and exacerbate environmental pollution.

To combat the negative impact of inorganic fertilizers, using organic fertilizers can be a decent strategy. In addition to being environmentally friendly, organic fertilizers can improve soil properties, porosity, and soil structure, as well as the soil's ability to retain water. One of the potential organic materials for that purpose is coffee grounds. A multitude of coffee cart shops has begun to thrive in various parts of Tarakan City. These shops not only offer more options to enjoy coffee but also afford an abundance of coffee grounds. Notwithstanding, while the habit of drinking coffee has flourished, many have overlooked the potential of coffee grounds. In fact, the distinctive aroma and delicious taste of brewed coffee are just a few of the valuable properties of coffee. Coffee grounds contain 2.28% nitrogen, 0.06% phosphorus, and 0.6% potassium (Febrian & Masjud, 2022). In addition, coffee grounds contain magnesium, sulfur, and calcium which are useful for plant growth (Hutomo *et al*., 2024). Nevertheless,

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coffee grounds are generally disposed right away, without further process for the hidden benefits. The use of coffee grounds not only reduces organic waste in landfills but also contributes to the environment and agricultural sustainability.

Another organic material that can be used to surmount the issues stemming from inorganic fertilizers is rice husk ash. The amount of rice husk in North Kalimantan follows provincial rice production. In 2021, rice production was estimated at 29.97 thousand tons of Dry Milled Grain (DMG). This volume was converted into 17.77 thousand tons of rice. Rice husk usually covers around 20% of the total weight of grain (Soltani *et al*., 2015). As such, processing 29.97 thousand tons of DMG may yield 5.99 thousand tons of rice husk. This shows potentially abundant rice husk, which can be used for various purposes, including biomass fuel or organic fertilizer. Rice husk ash contains crucial nutrients for plant growth and production, such as Nitrogen (N), Phosphorus (P), Potassium (K), Carbon (C), Ferric or iron (Fe), Magnesium (Mg), Aluminum (Al), and Manganese (Mn) (Das *et al*., 2022).

The combination of rice husk ash and coffee grounds is presumed to be an effective organic fertilizer for plant growth. Rice husk ash is rich in potassium, phosphorus, and microelements, while coffee grounds contain nitrogen, phosphorus, and potassium as well as other nutrients. The combination provides balanced and diverse nutrition, fostering plant growth and production. By mixing rice husk ash and coffee grounds in the right ratio, and then applying it to the soil in moderation, plants will afford sustainable benefits and maintain optimal growth. Furthermore, using organic materials helps maintain the soil ecosystem, while preventing environmental degradation.

Given the abovementioned findings, the present study aims to investigate the effect of application of coffee grounds and rice husk ash on the growth and yield of asparagus beans.

MATERIALS AND METHODS

Research Site and Treatments

The research was conducted in the experimental garden of the Faculty of Agriculture, Universitas Borneo, Tarakan. In this study, 5 ton/ha of chicken manure as fertilizer was used as the base fertilizer per plant two weeks before planting. Coffee grounds and rice husk ash were used one week before planting with the following treatments, P0: no coffee grounds and rice husk ash, P1: 1.5 ton/ha of coffee grounds, P2: 4 ton/ha of rice husk ash, P3: 0.75 ton/ha of coffee grounds and 2.0 ton/ha of rice husk ash, and P4: 1.5 ton/ha of coffee grounds and 4 ton/ha of rice husk ash. Using coffee grounds and rice husk ash was repeated when the plants were 14 DAP following thinning and 21 DAP, with the dose adjusted to the treatment.

Research Design

The study employed a Randomized Block Design (RBD) involving 1 factor with 5 treatments and 5 replications, totaling 25 experimental units. Each experimental unit comprised eight plants, arranged with a spacing of 40 cm by 50 cm. Soil processing was carried out 3 weeks before planting. Furthermore, beds were made measuring 1 x 1.5 meters with a bed height of 40 cm. The seeds were soaked in warm water for about 4 hours before planting at a depth of 5 cm. Two seeds were sown in each planting hole. After two weeks, the seedlings were thinned, retaining only one plant per hole. For high production, the peas were treated using stakes or trellises to propagate the plants. Wooden sticks or bamboo ranging from 150 to 200 cm long were used to support plants that either reached one week old or a height of approximately 25 cm. Weeding was done once every two weeks by removing weeds that could inhibit asparagus beans (*Vigna unguiculata* subsp. *Sesquipedalis*) growth. In the absence of rainfall, irrigation was conducted both in the morning and in the evening, with consistent volume of water.

Observation Parameters

The growth of asparagus beans was observed by measuring vegetative and generative parameters. The height increase was observed by measuring the weekly difference in average plant height until flowers grew. Plant height was measured from the ground surface to the growing point of the plant. The increase in the number of leaves was determined by the average weekly difference in the number of perfect leaves. The number of pods per plant, pod weight, and increase in length per pod were calculated for 1 month of harvest. Pod weight was measured by summing the weight of the pods per plant using an analytical scale. Meanwhile, the average length per pod (cm) was calculated from the base to the tip of the pod. To examine the treatment effects, the observed generative parameters were compared to the control, with the

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resultant differences signifying the effects. For generative parameters, treatment values were derived by calculating the difference between each treatment and the control group (P0). As a result, the control values are not displayed in the corresponding graphs. This method was employed to emphasize the relative effects of the treatments on generative outcomes.

RESULTS AND DISCUSSION

Vegetative Parameters (Plant Height (cm) and Number of Leaves)

The figure reports the increase in plant height from 7 DAP to 28 DAP in all treatments. Compared to the other treatments, the one involving 1.5 ton/ha of coffee grounds (P1) demonstrates the peak increase in height which is marked at 113.4 cm (Figure 1.). The same trend is also identified in the number of leaves, where P1 demonstrates the highest increase, with 38 strands (Figure 2)

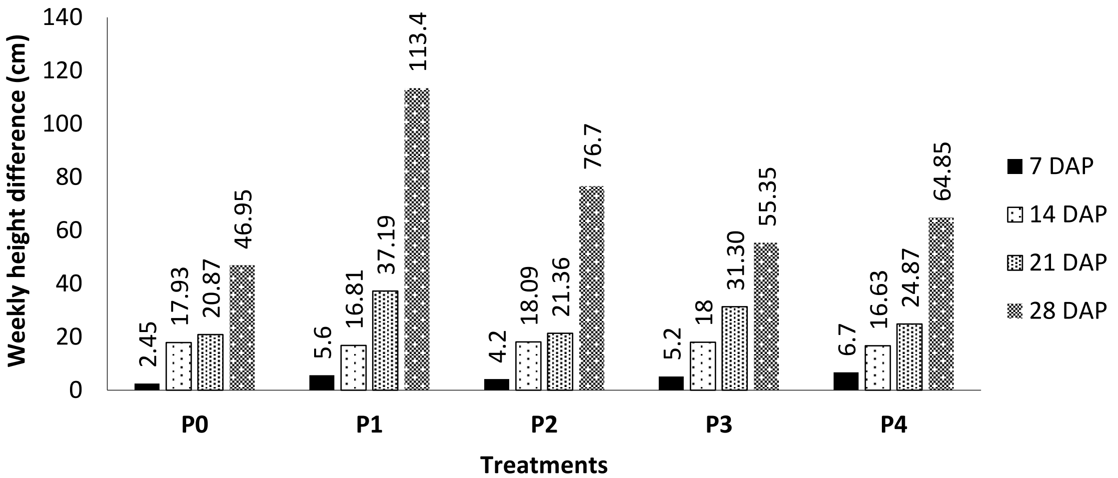

Figure 1. Weekly Growth Differences in Height (cm)

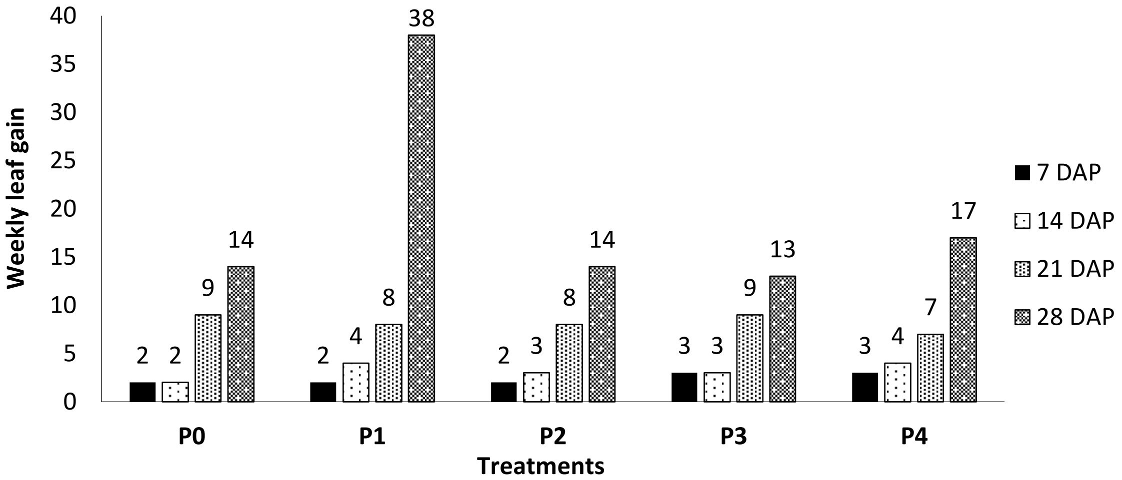

Figure 2. Weekly Leaf Count Difference

The parameters observed across treatments can be explained by the composition and balance of nutrients provided. Treatment P1 (1.5 tons/ha of coffee grounds) showed the highest increase in height and leaf count, particularly at 28 DAP, likely due to the high nitrogen content in coffee grounds. Nitrogen plays a vital role in chlorophyll synthesis and vegetative tissue development, which directly supports rapid vertical growth during early stages (Yang *et al.*, 2022). In contrast, P2 (4 tons/ha of rice husk ash) resulted in lower growth compared to P1, as rice husk ash is richer in potassium and silica, which are more associated with strengthening plant structure and enhancing stress resistance rather than rapid vegetative expansion *(Yadav et al.,* 2023). Combined treatments, such as P3 and P4, demonstrated more balanced

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and consistent growth, with P4 (higher combined dose) outperforming P3, suggesting that a synergistic effect arises from the combination of nitrogen and potassium sources. This synergy supports more optimal nutrient availability and uptake. According to Liebig's Law of the Minimum (Gaikwad, 2022), plant growth is limited by the scarcest nutrient; thus, treatments that provide a more complete and balanced nutrient profile, such as P4, tend to support better overall growth compared to single-nutrient treatments or the control (P0), which received no external nutrient input.

Optimal plant growth results from complex interactions between various environmental, genetic, and nutritional factors. The availability of sufficient and balanced nutrients is one of the key elements that determine the extent to which plants can grow optimally. Optimal nutrition not only supports vegetative plant growth but also affects the production of fruits. Without adequate nutrient, optimal plant growth will be impossible to take place. In the long run, this will significantly slow down the reproduction process. This finely aligns with Marginingsih *et al*. (2018) reporting that optimal plant growth is supported by optimal planting media and the presence of macro and micronutrients.

Generative Parameters (Number of Pods, Pods Length (cm) and Pods Weight (g))

The generative parameter observation affirms that using 1.5 ton/ha of coffee grounds (P1) yields the highest increase over the control and other treatments (Figures 3, 4, and 5). Application of 1.5 ton/ha of coffee grounds (P1) leads to the highest average increase in the number of pods, pod length (cm), and pod weight (g) compared to other treatments. P1 is characterized by 4 pods, each of which measures 4.01 cm and weighs 140.65 grams. The values represent the increase observed in each treatment compared to the control; therefore, the control is not displayed in the graph as its value would be zero.

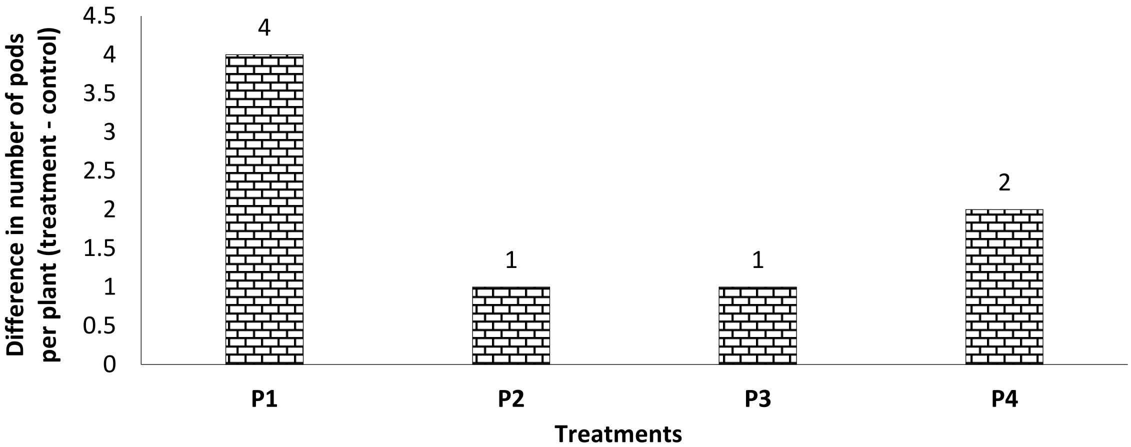

Figure 3.The Average Difference in The Number of Pods Per Plant Between The Treatment and Control

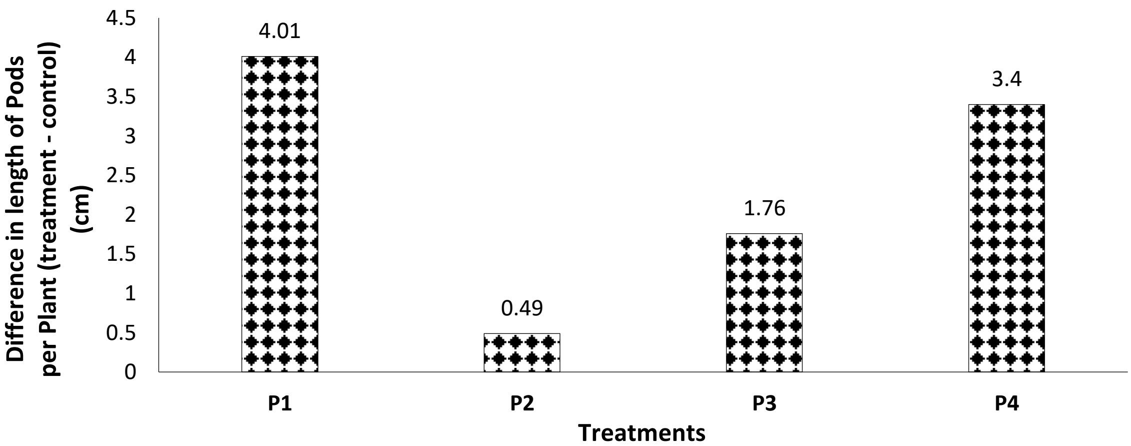

Figure 4.The Average Difference in The Length of Pods Per Plant Between The Treatment and Control (cm)

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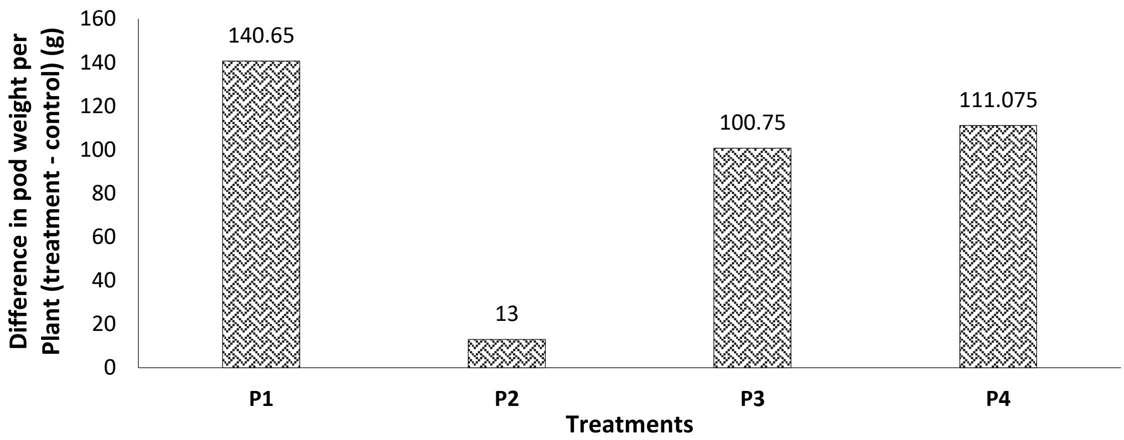

Figure 5.The Average Difference in Pod Weight Per Plant Between The Treatment and Control (g)

The generative parameter observations confirm that the application of 1.5 tons/ha of coffee grounds (P1) results in the most significant increase in pod number, pod length, and pod weight compared to the control and other treatments. This enhancement is likely due to the high organic matter and nitrogen content in coffee grounds, which play a crucial role not only in vegetative growth but also in supporting reproductive development. Nitrogen is essential for protein synthesis and enzyme activity, both of which are vital during flowering and fruit formation (Yang *et al.,* 2022). Additionally, coffee grounds improve soil structure and microbial activity, which enhances nutrient availability and uptake (Cervera-Mata *et al.,* 2018). Optimal nutrient supply especially nitrogen during reproductive stages boosts assimilate production and allocation to developing pods. Moreover, coffee grounds contain micronutrients such as phosphorus and potassium in smaller quantities, which further support fruit setting and filling (Ronga *et al.,* 2020). These combined factors likely contribute to the superior performance of P1 in generative traits. In contrast, treatments with rice husk ash (P2) or combined applications (P3 and P4) may offer balanced nutrients but do not provide the concentrated nitrogen effect needed to maximize pod development. Hence, P1 proves to be the most effective in enhancing the plant’s generative potential.

Nutrients are important for plant growth and production, including cell formation, energy metabolism, and synthesis of organic compounds. Inadequate nutrient availability will not enable optimal growth or harvest, particularly in challenging environmental conditions. As such, understanding the role of nutrients in plant growth, especially asparagus beans, is critical to achieving maximum production. Plant nutrients are divided into two main groups, namely macronutrients and micronutrients. Macronutrients are required by plants in large quantities, while micronutrients are needed in smaller amounts but are still highly crucial for plant growth (Johnson & Mirza, 2020).

The nutrients in coffee grounds are more suitable for the peas compared to rice husk ash. Likewise, suitable nutrient content plays a crucial role in optimizing plant growth and production. Elements such as nitrogen, phosphorus, and potassium determine the quality of various physiological processes in plants, from photosynthesis to protein synthesis. The right balance of nutrients can aid in the development of a strong root system, improve the quality of leaves and stems, and maximize yields. Conversely, suboptimal or excessive nutrients can inhibit growth and reduce productivity, making plants susceptible to disease and environmental stress. This finding underscores the essential of fine-cut understanding and management of nutrients to achieve optimal results in plant cultivation. According to Agam *et al.* (2020), coffee grounds contain 2.28% Nitrogen, 0.06% Phosphorus, and 0.6 Potassium with pH conditions ranging from 6.2. Ikhtianingsih & Frianto (2023) further states that coffee grounds contain magnesium, sulfur, and calcium necessary for plant growth. Another study acknowledges that coffee grounds are laden with C-organic (44.87%), N (1.69%), P (0.18%), K (2.49%), and Na (0.04%) (Kasongo *et al*., 2011). Meanwhile, rice husk ash contains higher levels of K, Si, and Fe, compared to other nutrients (Hisham & Ramli, 2021). Arman *et al*. (2020) points out that rice husk ash contains P (total) of 1.83%, K (total) of 1.48%, and N (total) of 1.07%. Finally, Singh *et al*. (2017) mentions that rice husk ash mainly consists of cellulose, in addition to lignin, silica, and water.

Although coffee grounds and rice husk ash contain nutrients critical to plants. Combining the two does not lead to elevated growth and production of asparagus beans, compared to the sole use of coffee grounds. This can occur due to the different properties of each material and its relationship to the

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properties of red-yellow podzolic soil. Coffee grounds are acidic so they will lower the soil pH, while rice husk ash has alkaline properties that can increase the soil pH. According to Winarti & Warsiyah (2018), coffee grounds are slightly acidic with a pH value of around 6.2. Meanwhile, Putra & Ekawati (2023) explains that the use of rice husk ash will reduce soil acidity. Yulianingsih (2020) argue that the provision of rice husk ash can neutralize the chemical properties of red-yellow podzolic soil (pH). The combination of the two causes the soil pH to become unstable and unsuitable for asparagus beans which require a slightly acidic pH. In the same vein, Purwono & Purnamawati (2007) explains that the soil acidity needed for maximum growth and yield of green beans is between 5.5 and 6.5 pH. The pH level for optimal growth and production of asparagus beans ranges between 6.84-6.89 (Hafiz *et al*., 2021). In addition to the acidity level, the decomposition time affects plant growth. Coffee grounds decompose faster and release nutrients into the soil faster, making them quickly available to plants. Although it provides long-term benefits such as adding silica, the release of nutrients from rice husk ash is slower than that of coffee grounds. Rice husks are highly resistant to moisture and fungal growth, which poses a challenge to its decomposition (Ola, 2017). The silica in rice husk ash also plays a role in the slow decomposition or degradation (Udjiana *et al*., 2022).

CONCLUSION

Based on the observations of both vegetative and generative parameters, the best treatment was achieved with the application of 1.5 tons/ha of coffee grounds (P1). Vegetatively, P1 showed the highest increase in plant height, number of leaves, and weekly growth rate. Generatively, P1 resulted in the greatest number of pods, longest pod length, and highest pod weight compared to other treatments and the control. The high nitrogen content in coffee grounds plays a vital role in supporting early vegetative growth as well as the optimal formation of reproductive organs. Therefore, P1 can be recommended as the most effective treatment to enhance overall plant growth and yield.

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