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Optimization of Soybean (*Glycine max* (L.) Merril) Growth and Yield Through the Application of Decanter Solid and Banana Peel Liquid Organic Fertilizer

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INFORMASI

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ABSTRACT

Soybeans (Glycine max (L.) Merril) are an essential food commodity and a source of vegetable protein. Soybean growth and yield can be improved by increasing soil fertility through organic matter. This study aimed to determine the optimal effect of a combination of decanter solids and banana peel POC on soybean growth and yield. This study used a Randomized Block Design (RBD) with nine treatment levels, The study used nine combinations of solid decanter dosages (5, 10, and 15 ton/ha) with POC banana peel fertilizer concentrations (10%, 30%, and 50%), namely: P1 (5 ton/ha + 10%), P2 (5 ton/ha + 30%), P3 (5 ton/ha + 50%); P4 (10 ton/ha + 10%), P5 (10 ton/ha + 30%), P6 (10 ton/ha + 50%); P7 (15 ton/ha + 10%), P8 (15 ton/ha + 30%), and P9 (15 ton/ha + 50%). Data were analyzed using analysis of variance (ANOVA) and followed by a DMRT test at the α=5% level. The application of a combination of a decanter solid and banana peel increased plant height, leaf number, pod number per plant, seed weight per plant, and yield per hectare. The application of 10 ton ha^{-1} of decanter solid + 10% banana peel POC was the best combination for increasing soybean growth and yield.

INTRODUCTION

Soybeans (Glycine max (L.) Merrill) are a strategic food crop because their seeds are a primary source of vegetable protein and the raw material for various processed products such as tempeh, tofu, soy sauce, tauco, and soy milk. Soybeans are relatively high in nutritional content, particularly protein (40–45%), fat (18%), carbohydrates (24–36%), and other dietary components beneficial to health (Aanchal, 2023). However, the increase in soybean consumption in Indonesia has not been matched by an increase in domestic production capacity. National soybean production data show fluctuations and a downward trend in recent years, making it a challenge to meet soybean demand (Siregar et al., 2024).

4,311.87 ton in 2023 (harvested area 2,837.20 ha; productivity 1.52 ton/ha) (DTPH Jambi Province, 2023). This decline in productivity indicates that increasing soybean yields remains a significant challenge, especially as national soybean demand continues to rise. Many factors, including the use of less-adaptive varieties, suboptimal cultivation practices, pest and disease pressure, and limited land conditions influence low soybean productivity (Dinas Tanaman Pangan, Hortikultura Dan Peternakan Provinsi Jambi, 2023).

One of the main obstacles to soybean cultivation in Jambi is the dominance of Ultisol soils, which cover approximately 39.93% of the region. Ultisols generally have a low pH (acidic), low organic matter content, high Al saturation, and low phosphorus (P) availability. This combination of characteristics makes Ultisols less supportive of optimal soybean growth, primarily because roots are easily disturbed

by acidity and Al toxicity. In contrast, P, an essential nutrient for root and pod formation, is bound and difficult for plants to access. Therefore, improving Ultisol quality is key to increasing soybean productivity, including through fertilization and the addition of organic matter/ameliorants.

Utilizing local organic waste can be a more efficient and sustainable solution. Decanter solids are solid waste from the palm oil processing process into crude palm oil (CPO) through decanter separation. This waste is brown in color and still contains approximately 1.5% oil residue (Palmasari et al., 2021). After undergoing composting/biodegradation, decanter solids have the potential to become organic fertilizers because they contain macronutrients such as N, P, K, and Mg. They also act as ameliorants, improving soil physical properties (looser structure, improved aeration, and increased water retention) and supporting soil biological activity. These improved soil conditions ultimately support better root development, resulting in more effective nutrient absorption (Prasetyo et al., 2022). Several studies have shown that decanter solids can improve plant performance: a combination of decanter solid compost 5 tons/ha with 10 tons/ha of chicken manure has been reported to improve soil chemical properties and increase soybean yield components (Duaja, 2021). In other crops, a dose of 10 tons/ha of decanter solid compost was reported to be the best treatment for supporting kale growth and yield (Madun et al., 2017). A combination of 15 tons/ha of decanter solid compost with 50% NPK fertilizer improved growth parameters and fresh weight of kale (Duaja et al., 2020).

In addition to basic fertilization with organic matter, increasing the availability of fast-acting nutrients can be achieved with liquid organic fertilizer (POC). POC is generally produced through fermentation with microorganisms (e.g., EM4), which accelerate the mineralization of organic matter, making nutrients more readily available and more easily absorbed by plants (Erickson et al., 2013). Banana peels were chosen as the POC material because they are readily available, have value as a waste product, and contain nutrients such as N, P, K, Ca, Mg, and Zn, which are essential for vegetative growth and yield formation. Susilawati et al. (2023) stated that agro-industrial waste materials, including banana peels, can be utilized as fertilizer. Research by Wahyuningsih et al. (2023) reported that banana peel fertilizer significantly affected plant height, the number of productive branches, and soybean yield components, with the best results at a dose of 300 ml L^{-1}. In other commodities, banana peel fertilizer has also been shown to increase growth and yield, for example, in eggplant (Kartana and Rahman, 2024).

Based on this description, decanter solid and banana peel fertilizer were chosen because they have complementary functions: decanter solid acts as a source of organic matter and a more gradual nutrient supplier while improving Ultisol quality, while banana peel fertilizer acts as a faster-absorbing nutrient supplier and supports plant physiological processes through the availability. Previous research has shown the presence of decanter solids in soybeans. Substitution of chemical fertilizer (NPK) with decanter cake (soybeans) was also reported to result in good growth and yield responses. Fifteen tons/ha + 50% NPK tended to have high values for growth components, while 10 tons/ha showed a good response in pod number. (Duaja, et al., 2020).

METHODS

The research was conducted from March to July 2025 at the Teaching and Research Farm, Faculty of Agriculture, University of Jambi, UNJA Mendalo Campus. The equipment used included 40 x 70 cm burlap sacks, 3 x 4 meter tarpaulins with a thickness of 0.75 mm, 80-liter buckets, 15-meter tape measures, rulers, watering cans, hoes, nets, label boards, analytical scales, hygrometers, soil thermometers, machetes, measuring cups, ovens, scissors, envelopes, raffia rope, plastic, stationery, and cameras. The materials used included Dering 3 soybean seeds, solid decanters fermented with EM4 composting material for 8 weeks and then dried for 2 weeks, liquid organic fertilizer (POC) made from banana peels fermented with EM4 for 2 weeks, water, Legin, and the pesticides Dithane M-45 80 WP and Decis 25 EC.

Table 1. Nutrient content of banana peel POC, and decanter solid

Parameter	Banana Peel POC	Decanter Solid
pH	3,73	7,37
N (%)	0,02	3,47
P (%)	0,014	0,38
K (%)	0,44	1,70
Mg (%)	0,02	0,32
Zn (%)	2.15	0,96
Total-Organik Carbon (%)	0,52	30,10
C/N Ratio	24, 34	8,67

Table 2. Chemical properties of soil before Treatment

Parameter	Result
pH	6,6
Total N (%)	0,15
P_2O_5 in 25% HCl (mg/100 g)	60,53
K_2O in 25% HCl (mg/100 g)	33,75
Ca in 25% HCl (mg/100 g)	54,93
Mg in 25% HCl (mg/100 g)	17,86
Total-Organik Carbon (%)	1,56

This study used a Randomized Block Design (RBD) with one factor: a combination of Decanter Solid with Banana Peel POC. From this design, 9 treatment combinations were obtained as follows: P1 = decanter solid 5 ton/ha + POC banana peel concentration 10%, P2 = decanter solid 5 ton/ha + POC banana peel concentration 30%, P3 = decanter solid 5 ton/ha + POC banana peel concentration 50%, P4 = decanter solid 10 ton/ha + POC banana peel concentration 10%, P5 = decanter solid 10 ton/ha + POC banana peel concentration 30%, P6 = decanter solid 10 ton/ha + POC banana peel concentration 50%, P7 = decanter solid 15 ton/ha + 10% banana peel organic fertilizer, P8 = decanter solid 15 ton/ha + 30% banana peel organic fertilizer, P9 = decanter solid 15 ton/ha + 50% banana peel organic fertilizer.

The study began by tilling the soil using a tractor and creating research beds. Chicken manure was applied as a base fertilizer and incubated for 1 week. Each bed was then fertilized with a solid decanter according to the specified treatment. Dering three soybean seeds were mixed with legumes, then planted in the prepared planting holes. Liquid organic fertilizer (POC) made from banana peels was applied from 2 to 6 weeks after planting. Plant care included watering, pest control, and weed control to ensure optimal growth. Harvesting was carried out when the plants reached 12 weeks of age or when most of the leaves turned yellow and fell off, and the pods turned brown.

Observed variables included plant height (cm), measured with a tape measure from the base of the stem above ground level to the last growing point. The number of leaves (leaflets), especially fully developed (trifoliate) leaves, was counted weekly. The number of pods per plant was calculated by collecting all filled pods from sample plants after harvest. Seed weight per plant (g) was determined by weighing the seeds from each sample plant using an analytical balance. To obtain the weight of 100 seeds (g), 100 seeds were randomly selected from each sample plant and then weighed. Yield per hectare (tons/ha) was calculated by weighing all seeds in the plot and dividing by the plot area. Plant nutrient uptake during the R5 phase (mg per plant) was measured by drying the plants in an oven during this phase, weighing the dried plants, and analyzing their nutrient content in the laboratory. Observational data were analyzed statistically using analysis of variance (ANOVA), and differences between treatments were determined using Duncan's Multiple Range Test at $\alpha = 5\%$.

RESULTS AND DISCUSSION

Plant height

Plant height was measured weekly from 2 to 6 weeks after planting. Analysis of variance (ANOVA) results showed that the application of decanter solid compost and banana peel POC affected soybean height at 6 weeks after planting. The average soybean height is shown in Table 3.

Table 3. Average height of soybean plants 6 weeks post-fertilization with the provision of Decanter Solid and Banana Peel POC

Combination of Decanter Solid + Banana Peel POC	Plant Height
5 $ton\ ha^{-1}$ + 10%	69,88 ± 2,51 c
5 $ton\ ha^{-1}$ + 30%	72,17 ± 1,42 bc
5 $ton\ ha^{-1}$ + 50%	73,58 ± 4,46 bc
10 $ton\ ha^{-1}$ + 10%	72,75 ± 0,66 bc
10 $ton\ ha^{-1}$ + 30%	75,17 ± 2,68 abc
10 $ton\ ha^{-1}$ + 50%	77,58 ± 0,65 abc
15 $ton\ ha^{-1}$ + 10%	78,83 ± 0,30 ab
15 $ton\ ha^{-1}$ + 30%	83,00 ± 4,38 a
15 $ton\ ha^{-1}$ + 50%	80,00 ± 0,76 ab

Note: Numbers followed by the same letter are not significantly different at the DMRT level of α 5%; ± = Standard Error.

Table 3 shows that the addition of 15 ton/ha decanter solid with 30% banana peel POC produced the highest average value. Furthermore, the treatment of 10 ton/ha decanter solid with 30% and 50% banana peel POC concentrations, as well as the treatment with 15 ton/ha decanter solid with 10% and 50% banana peel POC concentrations, showed the same effect. In contrast, the treatment of 5 ton/ha decanter solid with 10% banana peel POC produced the lowest average value. These results indicate that increasing the dose of organic matter, especially decanter solids, enhances vegetative growth of soybeans. The increase in plant height is due to the high levels of essential nutrients, such as nitrogen (N), phosphorus (P), and potassium (K), in decanter solids. Furthermore, the potassium content in banana peel organic fertilizer supports metabolism and cell division, thus contributing to increased plant height. This is consistent with the statement by Amalia et al., (2023) that the presence of N, P, and K nutrients can increase meristematic cell activity at plant tips, thereby optimizing photosynthesis. By increasing photosynthesis, plant growth also increases.

Leaf Number

The number of leaves was counted weekly, starting at 2 weeks after planting and ending at 6 weeks after planting. Analysis of variance results showed that the application of decanter solid compost and liquid organic fertilizer (POC) from banana peels significantly affected the number of leaves in soybean plants at 6 weeks after planting. The average number of leaves is shown in Table 4.

Table 4. Average number of leaves in soybean plants at 6 weeks after planting with decanter solid compost and liquid organic fertilizer from banana peels

Combination of Decanter Solid + Banana Peel POC	Number of Leaves
5 $ton\ ha^{-1}$ + 10%	22,08 ± 3,00 c
5 $ton\ ha^{-1}$ + 30%	27,17 ± 0,36 bc
5 $ton\ ha^{-1}$ + 50%	26,75 ± 3,54 bc
10 $ton\ ha^{-1}$ + 10%	32,92 ± 2,50 ab
10 $ton\ ha^{-1}$ + 30%	29,50 ± 2,13 abc
10 $ton\ ha^{-1}$ + 50%	37,25 ± 0,80 a
15 $ton\ ha^{-1}$ + 10%	30,00 ± 3,27 abc
15 $ton\ ha^{-1}$ + 30%	26,83 ± 1,58 bc
15 $ton\ ha^{-1}$ + 50%	35,58 ± 3,73 ab

Note: Numbers followed by the same letter are not significantly different at the 5% α level.; ± = Standard Error.

Table 4 shows that the application of 10 ton/ha decanter solid compost + 50% banana peel POC yielded the highest average. Likewise, the treatment of 10 ton/ha decanter solid with 10% and 30% banana peel POC concentration, and the treatment of 15 ton/ha decanter solid with 10% and 50% banana peel POC concentration, showed the same effect. The treatment of 5 ton/ha decanter solid + 10% banana peel POC showed the lowest average. The increase in leaf number was accompanied by higher plant height, reflecting increased photosynthesis and plant productivity. This is influenced by the nutrient content of the decanter solidand banana peel POC. According to Tuapattinaya and Tutupoly, (2014), nitrogen plays an important role in stimulating the growth of plant parts such as stems, branches, leaves, and roots, and is essential for the formation of proteins, fats, and other compounds. Furthermore, nitrogen is involved in the formation of chlorophyll, which is essential for photosynthesis. Potassium supports the formation of proteins and carbohydrates and helps strengthen plants, preventing leaves, flowers, and fruit from dropping easily. Magnesium, on the other hand, plays a role in water absorption, which allows plant cells to divide and grow effectively.

Number of Pods per Plant

The number of pods per plant was observed after harvest, at 12 weeks after planting. Analysis of variance results showed that the addition of decanter solid and banana peel fertilizer significantly affected the number of pods per plant. The average number of pods per plant is presented in Table 5.

Table 5. Average number of pods per plant with the combination of decanter solid and banana peel fertilizer

Combination of Decanter solid+ Banana Peel POC	Number of Leaves
5 $ton\ ha^{-1}$ + 10%	96,00 ± 5,28 c
5 $ton\ ha^{-1}$ + 30%	103,33 ± 3,86 bc
5 $ton\ ha^{-1}$ + 50%	106,00 ± 2,82 bc
10 $ton\ ha^{-1}$ + 10%	115,50 ± 10,45 abc
10 $ton\ ha^{-1}$ + 30%	128,08 ± 4,01 a
10 $ton\ ha^{-1}$ + 50%	120,92 ± 10,30 ab
15 $ton\ ha^{-1}$ + 10%	123,50 ± 2,60 ab
15 $ton\ ha^{-1}$ + 30%	117,42 ± 8,23 ab
15 $ton\ ha^{-1}$ + 50%	110,50 ± 4,55 abc

Note: Numbers followed by the same letter are not significantly different at the 5% α level of DMRT.
; ± = Standard Error.

The table shows that the 10 ton/ha decanter solid treatment combined with 30% banana peel POC produced the highest average value. Furthermore, the 10 ton/ha decanter solid treatment combined with 10% and 50% banana peel POC concentrations, and the 15 ton/ha decanter solid treatment combined with 10%, 30%, and 50% banana peel POC concentrations had similar effects. Conversely, the 5 ton/ha decanter solidt reatment combined with 10% banana peel POC yielded the lowest average. This combination of organic matter also significantly impacted the number of pods per plant. These results indicate that this combination provides sufficient nutrients to support the plant's generative phase, particularly flower and pod formation. According to Kaya et al., (2017), the nutrient content in solid decanters, particularly macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), can meet plant nutrient needs and prevent nutrient deficiencies. Phosphorus is an essential nutrient that plays a vital role in seed formation. (Bakhtiar et al. (2014) found that adequate phosphorus availability increased seed yield, while low phosphorus availability negatively impacted pod filling and suboptimal seed formation. Research by Prasetyo et al. (2022) also showed that organic matter can increase soil biological activity, thereby supporting decomposition. Effective decomposition increases nutrient availability to plants, thereby increasing metabolic activity, particularly photosynthesis, and allowing the resulting photosynthetic products to be transported for pod formation.

Seed Weight per Plant

Seed weight per plant was calculated after harvest and pod separation. Analysis of variance results showed that the addition of decanter solid compost and banana peel biofertilizer significantly increased seed weight per plant. The average seed weight per plant is shown in Table 6.

Table 6. Average seed weight per plant with Decanter Solid and Banana Peel Biofertilizer

Combination of Decanter solid+ Banana Peel POC	Number of Leaves
5 $ton\ ha^{-1}$ + 10%	32,32 ± 1,61 c
5 $ton\ ha^{-1}$ + 30%	35,22 ± 4,18 bc
5 $ton\ ha^{-1}$ + 50%	38,11 ± 2,69 bc
10 $ton\ ha^{-1}$ + 10%	40,31 ± 3,08 abc
10 $ton\ ha^{-1}$ + 30%	46,66 ± 2,49 a
10 $ton\ ha^{-1}$ + 50%	38,91 ± 1,88 abc
15 $ton\ ha^{-1}$ + 10%	41,94 ± 0,82 ab
15 $ton\ ha^{-1}$ + 30%	39,92 ± 3,64 abc
15 $ton\ ha^{-1}$ + 50%	34,88 ± 1,63 bc

Note: Numbers followed by the same letter are not significantly different at the DMRT level of α 5% ; ± = Standard Error

Table 6 shows that the decanter solidand banana peel POC treatments affected seed weight per plant. The application of 10 ton/ha decanter solid + 30% banana peel POC showed the highest average. Likewise, the decanter solidtreatment of 10 ton/ha with banana peel POC concentrations of 10% and 50% and the decanter solid treatment of 15 ton/ha with banana peel POC concentrations of 10% and 30% showed the same effect. The decanter solid treatment of 5 ton/ha + 10% banana peel POC showed the lowest average. The combination of decanter solid and banana peel organic fertilizer (POC) treatment significantly affected seed weight per plant, with the highest seed weight being 46.66 grams

in the 10 ton/ha decanter solid + 30% banana peel organic fertilizer (POC) treatment. This impact is due to the ability of decanter solid compost and banana peel liquid organic fertilizer (POC) to provide sufficient nutrients, improve soil structure, and increase soil microbial activity. A balanced supply of nitrogen (N) encourages the formation of amino acids and proteins in seeds, allowing for optimal pod filling. Nitrogen absorbed by plants from the soil is initially stored in the stems and leaves, then transferred to the pods. As the pods mature, most of the nitrogen (around 30–90%) is absorbed into the seeds (Ariani et al., 2023).

100-Seed Weight

The weight of 100 seeds was observed after harvesting and pod removal. Analysis of variance results showed that the addition of decanter solid compost and banana peel POC affected the weight of 100 seeds. The average weight of 100 seeds is shown in Table 7.

Table 7. Average weight of 100 seeds with decanter solid compost and banana peel POC

Combination of Decanter Solid+ Banana Peel POC	Number of Leaves
5 $ton\ ha^{-1}$ + 10%	16,59 ± 0,19
5 $ton\ ha^{-1}$ + 30%	16,61 ± 0,87
5 $ton\ ha^{-1}$ + 50%	16,85 ± 0,33
10 $ton\ ha^{-1}$ + 10%	16,62 ± 0,27
10 $ton\ ha^{-1}$ + 30%	16,30 ± 0,48
10 $ton\ ha^{-1}$ + 50%	17,22 ± 0,56
15 $ton\ ha^{-1}$ + 10%	16,82 ± 0,46
15 $ton\ ha^{-1}$ + 30%	15,96 ± 0,06
15 $ton\ ha^{-1}$ + 50%	16,25 ± 0,16

Note: Numbers followed by the same letter are not significantly different at the 5% α level of DMRT.
; ± = Standard Error.

Table 7 shows that the application of decanter solid compost and banana peel POC treatments did not affect the weight of 100 seeds. The application of 10 ton/ha decanter solid + 50% banana peel POC showed the highest average. The treatment of 15 ton/ha decanter solid + 30% banana peel POC showed the lowest average. However, based on the analysis results, the combination of decanter solid compost and banana peel POC did not significantly affect the weight of 100 seeds in all treatments. This is suspected because the weight of 100 seeds is more strongly influenced by the genetic factors of the variety and the microecological conditions where the seeds develop. Factors such as temperature, humidity, and water availability also influence seed size and density, which ultimately affect the weight of 100 seeds. Treatment with 10 ton/ha of Decanter Solids and 50% POC from banana peels produced the highest average weight per 100 seeds, namely 17.22 grams. Compared to the weight of 100 seeds of the Dering 3 variety of soybean which was only 14.9 grams, the seed weight in this study exceeded the standard by 2.32 grams. This shows that the addition of 10 ton/ha decanter solids with 50% POC from banana peels can increase the weight of 100 soybean seeds optimally.

Yield per Hectare

Yield per hectare was observed after harvesting and pod separation. Analysis of variance results showed that the addition of decanter solid compost and banana peel fertilizer (POC) had a significant impact on yield per hectare. Average yield per hectare is presented in Table 8.

Table 8. Average yield per hectare with the combination of decanter solid compost and banana peel fertilizer.

Combination of Decanter Solid+ Banana Peel POC	Yield per Hectare
5 $ton\ ha^{-1}$ + 10%	1,87 ± 0,08 d
5 $ton\ ha^{-1}$ + 30%	2,30 ± 0,32 bcd
5 $ton\ ha^{-1}$ + 50%	2,05 ± 0,10d
10 $ton\ ha^{-1}$ + 10%	2,62 ± 0,02 abc
10 $ton\ ha^{-1}$ + 30%	3,05 ± 0,11 a
10 $ton\ ha^{-1}$ + 50%	2,69 ± 0,17 ab
15 $ton\ ha^{-1}$ + 10%	2,08 ± 0,19 cd
15 $ton\ ha^{-1}$ + 30%	2,41 ± 0,17 bcd
15 $ton\ ha^{-1}$ + 50%	2,60 ± 0,09 abc

Note: Numbers followed by the same letter are not significantly different at the 5% α level of DMRT.
; ± = Standard Error.

Table 8 shows that the application of 10 ton/ha decanter solid + 30% banana peel POC showed the highest average. Likewise, the treatment of 10 ton/ha decanter solid with 10% and 50% banana peel POC concentrations and the treatment of 15 ton/ha decanter solid with 50% banana peel POC concentration showed the same effect. The treatment of 5 ton/ha decanter solid + 10% banana peel POC showed the lowest average. The yield per hectare parameter indicates that the combination of treatments significantly affected soybean productivity. The best treatment was achieved with a combination of 10 ton/ha decanter solid + 30% banana peel POC with a yield of 3.05 tons/ha. This yield is higher than the treatment of 5 ton/ha decanter solid + 10% banana peel POC which only produced 1.87 ton/ha. This increase in yield is consistent with the increase in other agronomic parameters, confirming that this combination is the optimum dose capable of providing balanced plant nutrient needs. These results are consistent with the findings of Latif et al. (2017), who found that pod weight per bed is positively correlated with pod weight per plant and yield per hectare. Plants do not grow optimally at either the vegetative or generative stages if their nutrient needs are not met. Maryati et al. (2014) noted that one way to increase the efficiency of plant nutrient absorption is by adding soil amendments in the form of solid palm oil waste from decanters. Research by Laili (2022) also showed that soybean size is highly dependent on the plant's ability to transport assimilates into the seed. Potassium (K) acts as an enzyme activator, while phosphorus (P) accelerates pod ripening. Adequate K and P levels have a positive impact on soybean yield.

Nutrient Uptake in R5 Plants

Nutrient uptake calculations for R5 phase plants were conducted at the end of the study. Laboratory analysis results showed that N, P, and K nutrient uptake in R5 phase soybean plants differed between treatments. The results of N, P, and K nutrient uptake in R5 phase soybean plants are shown in Table 9.

Table 9. Effect of the combination of decanter solids and banana peel organic fertilizer on nutrient uptake in the R5 phase.

Decanter Solid + Banana Peel POC	Nutrient Absorption		
	N (mg/plant)	P (mg/plant)	K (mg/plant)
5 $ton\ ha^{-1}$ + 10%	299,25	32,40	243,20
5 $ton\ ha^{-1}$ + 30%	415,00	42,00	251,25
5 $ton\ ha^{-1}$ + 50%	409,20	39,96	283,20
10 $ton\ ha^{-1}$ + 10%	363,83	41,28	271,95
10 $ton\ ha^{-1}$ + 30%	344,40	40,08	295,20
10 $ton\ ha^{-1}$ + 50%	471,15	49,28	341,55
15 $ton\ ha^{-1}$ + 10%	465,13	63,75	384,30
15 $ton\ ha^{-1}$ + 30%	491,35	54,41	359,60
15 $ton\ ha^{-1}$ + 50%	505,88	52,16	346,28

Table 9 shows that the uptake of nitrogen (N), phosphorus (P), and potassium (K) nutrients in soybeans in the R5 phase varied depending on the treatment. Nitrogen uptake ranged from 0299.25 to 505.88 mg/plant, with the highest value achieved in the 15 ton/ha decanter solid treatment with 50% banana peel POC, while the lowest value was observed in the 5 ton/ha decanter solid treatment with 10% banana peel POC. Phosphorus uptake was relatively lower than nitrogen and potassium uptake, ranging from 32.40 to 63.75 mg/plant. The highest value for phosphorus uptake was achieved in the 15ton/ha decanter solid treatment with 10% banana peel POC, while the lowest value was observed in the 5 ton/ha decanter solid treatment with 10% banana peel POC. Potassium uptake increased in treatments P1 to P7, ranging from 243.20 to 384.30 mg/plant, but decreased by 359.60 mg/plant and 346.285 mg/plant in treatments P8 and P9, respectively.

The highest potassium uptake value was recorded in the 15 ton/ha decanter solid treatment with 10% banana peel POC, while the lowest value was recorded in the 5 ton/ha decanter solid treatment with 10% banana peel POC. The high nitrogen (N) uptake in the 15 ton/ha decanter solid treatment with 50% banana peel POC is closely associated with higher plant growth and leaf number. Nitrogen is an important component in chlorophyll formation, so increased nitrogen uptake contributes to higher chlorophyll content, especially in the R5 phase, which is higher than in the V4 phase. This fact underscores the important role of nitrogen in vegetative growth and photosynthesis, which, in turn, affects pod number and seed weight per plant. This statement is consistent with the opinion of Usman et al. (2014) in Iswiyanto et al. (2022), which states that nitrogen stimulates overall plant growth and chlorophyll formation.

Although phosphorus (P) uptake is relatively low, this element still plays a crucial role in supporting flowering, pod formation, and seed filling. The 15 ton/ha decanter solid treatment with 50% banana peel POC, which achieved the highest P uptake, showed quite good results in terms of pod number and seed weight. Phosphorus plays a role in energy metabolism via ATP and is therefore crucial during the generative phase of soybean development. According to Sari et al. (2017), low phosphorus availability in Ultisol soils is usually caused by fixation by aluminum (Al) and iron (Fe), so the use of a combination of organic fertilizers can help increase phosphorus availability for plants.

Potassium (K) uptake increased with increasing decanter solid dosage and banana peel POC concentration, but decreased with 15 ton/ha decanter solid application with 30% and 50% banana peel POC concentrations. This indicates that at high dosages and concentrations, the plant's potassium needs are met, so additional uptake is insignificant. These results are consistent with research showing that high potassium uptake treatments also result in greater pod number and higher seed weight. Hendrival et al. (2014) noted that potassium deficiency during pod formation and seed filling can reduce the number of pods and seeds per plant. Physiologically, potassium plays a role in carbohydrate metabolism, including the formation, breakdown, and translocation of starch within plant tissues, as well as in nitrogen metabolism and protein synthesis.

CONCLUSION

In conclusion, the combination of decanter solid and banana peel POC has been proven to increase soybean growth and yield, as seen from the increase in plant height, number of leaves, number of pods per plant, seed weight per plant, and yield per hectare. Based on the results of the ANOVA analysis followed by the DMRT test ($\alpha = 5\%$), the treatment of 10 ton/ha decanter solid + 10% banana peel POC (P4) showed the most optimal response compared to other treatments, so it can be stated as the best combination to increase soybean productivity through improving soil fertility based on organic matter.

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