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THE UTILIZATION OF CAJUPUT LEAF WASTE AS ORGANIC FERTILIZER ON PLANT TOMATOES GROWTH AND DEVELOPMENT

PEMANFAATAN LIMBAH DAUN KAYU PUTIH SEBAGAI PUPUK ORGANIK PADA PERTUMBUHAN DAN PERKEMBANGAN TANAMAN TOMAT

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Abstract

The annual production of cajuput oil in Indonesia can reach 88,607 tons. This has implications on the accumulation of waste. One of the efforts to reduce the amount of cajuput waste is to use this waste as organic fertilizer. This study aimed to determine the content of C, N, P, and K of cajuput leaf waste fertilizer and their effect on the growth and development of tomato plants (*Lycopersicum esculentum* L.). This study used a Completely Randomized Design (CRD) with P0+ treatment (EM4 fertilizer); P0- (no fertilizer); and treatment with the ratio (%) of cajuput leaf waste fertilizer: chicken manure, including P1 (100:0); P2 (75:25); P3(50:50); P4 (25:75); P5(0:100). The results showed that P2 treatment had a higher content of N-total (2.82%) and C-Organic (44.28%) with a C/N ratio of 15.70%, directly proportional to the results of the best vegetative growth response, indicated by a plant height of 125.75 cm, stem diameter 0.665 cm, and the 15.75 number of leaves. The P2 treatment was considered to be the best for tomato plant development by producing fruit sizes (diameter; length) up to 3.40 cm; 3.49 cm with a weight of 20 g.

Keywords: Cajuput leaf waste, Organic fertilizer, Tomato

Abstrak

Produksi tahunan minyak kayu putih di Indonesia bisa mencapai 88.607 ton. Hal ini berimplikasi pada penumpukan sampah. Salah satu upaya untuk mengurangi jumlah limbah daun kayu putih adalah dengan memanfaatkan limbah tersebut sebagai pupuk organik. Penelitian ini bertujuan untuk mengetahui kandungan C, N, P, dan K pupuk limbah daun kayu putih serta pengaruhnya terhadap pertumbuhan dan perkembangan tanaman tomat (Lycopersicum esculentum L.). Penelitian ini menggunakan Rancangan Acak Lengkap (RAL) Perlakuan P0+ (pupuk EM4); P0- (tanpa pupuk); dan perlakuan dengan perbandingan (%) pupuk limbah daun kayu putih dengan kotoran ayam, di antaranya P1 (100:0); P2 (75:25); P3 (50:50); P4 (25:75); P5 (0:100). Hasil penelitian menunjukkan bahwa perlakuan P2 memiliki kandungan N-total (2,82%) dan C-Organik (44,28%) yang lebih tinggi dengan rasio C/N 15,70%, berbanding lurus dengan hasil respon pertumbuhan vegetatif terbaik yang ditunjukkan oleh tinggi tanaman 125,75 cm, diameter batang 0,665 cm dan jumlah daun 15,75. Perlakuan P2 dinilai paling baik untuk perkembangan tanaman tomat dengan menghasilkan ukuran buah (diameter; panjang) hingga 3,40 cm; 3,49 cm dengan berat 20 g.

***Kata Kunci**: Limbah daun kayu putih, Pupuk organik, Tomat*

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INTRODUCTION

Cajuput oil production in Indonesia as one of the forestry sector industries has experienced rapid growth and increasing demand. According to The Ministry of Environment and Forestry of the Republic of Indonesia (2013), Indonesian cajuput oil has reached an annual production of 88.607 tons. This increase in production has implications for the amount of waste produced, as cajuput oil processing has a yield value of 0.76%. This condition causes a large accumulation of waste, as has occurred in the area of The Cajuput Oil Factory Jatimunggul, Indramayu Regency, West Java. Kartikasari (2007) reported that only 30% of the cajuput dry waste was used as boiler fuel. Rifai (2015) added that only half of the waste produced can be used as a by-product while the rest was abandoned.

The Indonesian Fertilizer Producers Association (2018) reported an increase in 2017 organic fertilizer production of 868.871 tons/year, compared to the previous year's production of 589.709 tons/year. The commonly used organic fertilizers are manure such as chicken, goat, and cow manure. Afrilliana et al. (2017) mentioned that chicken manure contains 1.3% N, 1.3% P_2O_5, and 0.8% K_2O. Goat manure contains elements of N 0.60%, P_2O_5 0.30%, and K_2O 0.17%, while cow manure contains elements of N 0.40%, P_2O_5 0.20%, and K_2O 0.10%.

Currently, the potential of cajuput leaf waste as an alternative fertilizer for the growth and development of tomato plants has not been studied. However, several studies reported that cajuput leaf waste can be used as fertilizer and positively influence the growth of cajuput seedlings (Rahmawati, 2016; Widyaningsih, 2002). Soekotjo (1996) stated that cajuput leaf waste itself contains C-organic (47.93%), total N (2.22%), phosphorus (61.20 ppm), and potassium/ (3.12 me/100g). To further increase its potential, the use of organic fertilizers can be combined or mixed with other organic fertilizers.

MATERIAL AND METHODS

Sample Preparation

This research was an experimental study conducted from March until October 2021. The cajuput leaf waste with a shelf life of 3–5 years was taken from The Cajuput Oil Factory Jatimunggul combined with a mixture of chicken manure. The fertilizer was then applied to tomatoes (PERMATA F1 varieties) after seeding.

Design Experiment

The research was a completely randomized design with seven treatments and four replications. The treatments provided include P0 (+)= positive control (fertilizer using EM4); P0 (-)= negative control (no fertilizer treatment/untreated control); P1= treatment 1 (100% cajuput leaf waste fertilizer); P2= treatment 2 (75% cajuput leaf waste fertilizer + 25% manure); P3= treatment 3 (50% cajuput leaf waste fertilizer + 50% manure); P4= treatment 4 (25% cajuput leaf waste fertilizer + 75% manure); and P5= treatment 5 (100% manure).

Data Analysis

The data were analyzed using *ANOVA*, if F-count > F-table then continued with *Duncan's test*.

RESULTS

The Cajuput Leaf Waste Fertilizer condition and content

There were five types of fertilizers among seven treatments, given to tomato plants with different nitrogen (N), phosphorus (P), potassium (K), and carbon (C) content. As presented in Table 1, the P2 treatment (75% cajuput leaf waste fertilizer + 25% manure) had higher C (44.28%) and N (2.82%) content than other treatments. In addition, the highest P_2O5 content found in the P4 treatment of 1.63%, while the highest K_2O content of 0.8% was found in the P5 treatment. The pH values for all fertilizer treatments were in the standard range (Table 2). This indicates that this fertilizer is in suitable requirement for plant growth.

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Table 1. Carbon (C), nitrogen (N), phosphorus (P), and potassium (K) content in of the treatment fertilizer

Parameter	Unit	Results					Standard
		P1	P2	P3	P4	P5	
C-organik	%	20.08	44.28	39.27	32.93	1.5	≥15
C/N	-	11.21	15.70	18.52	18.71	11	15–25
N-total	%	1.79	2.82	2.12	1.76	1.5	<6
P_2O_5	%	1.25	0.91	1.19	1.63	1.3	<6
K_2O	%	0.61	0.45	0.29	0.42	0.8	<6

Table 2. Average pH of treatment fertilizer

Treatments	pH	Standard value*
P1	6.4	
P2	6.2	
P3	6.4	4–8
P4	6.4	
P5	6.6	

Source: *= The Regulation of Minister of Agriculture (2011) No.70/Permentan/SR.140/10/2011

Plant Height

Based on statistical tests, all fertilizer treatments significantly increased the plant height compared to the control (P >0.05), however, it was not significantly different among the fertilizer treatments (P1, P2, P3, P4, P4, and P5) (Figure 1). This is because of slightly similar fertilizer content among the five treatments.

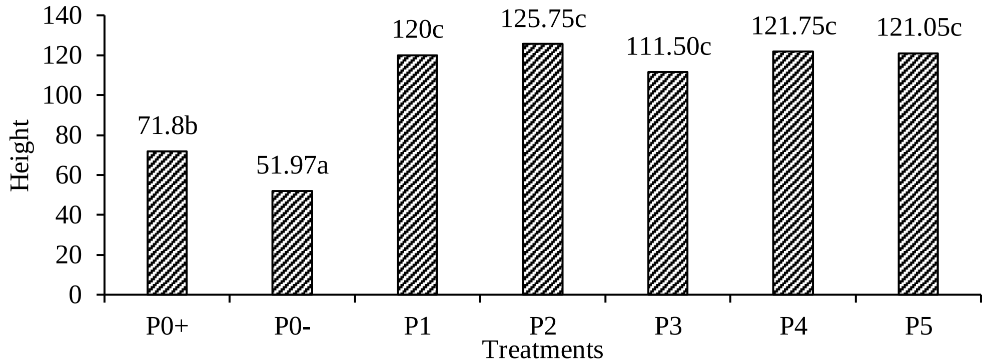

Figure 1. Effect of cajuput leaf waste fertilizer treatments on tomato plants' height at 6-weeks after planting (WAP). The numbers followed by the same letters in the same column show no significant difference based on Duncan's test at the 95% significance level

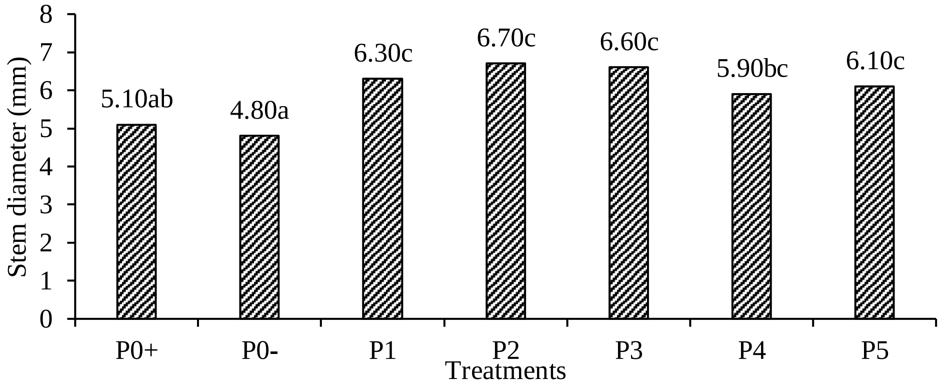

Figure 2. Effect of cajuput leaf waste fertilizer treatment on the tomato stems' diameter at 6-weeks after planting (WAP). The numbers followed by the same letters in the same column show no significant difference based onDuncan's test at the 95% significance level

Stem Diameter

All fertilizer treatments significantly increased the stem diameter of tomato plant compared to the control, although significance was not found between treatments (Figure 2). Applying fertilizer in each treatment had relatively the same effect on the increase in tomatoes' stemdiameter. This is might due to each treatment having the relatively same range of nutritional values, especially N.

Number of Leaves

The same results were shown on the number of leaves (Figure 3). All fertilizer treatments (P1, P2,P3, P4, P5) significantly increased the number of leaves in the tomato plants compared to control. However, it was not significant if compared between treatments.

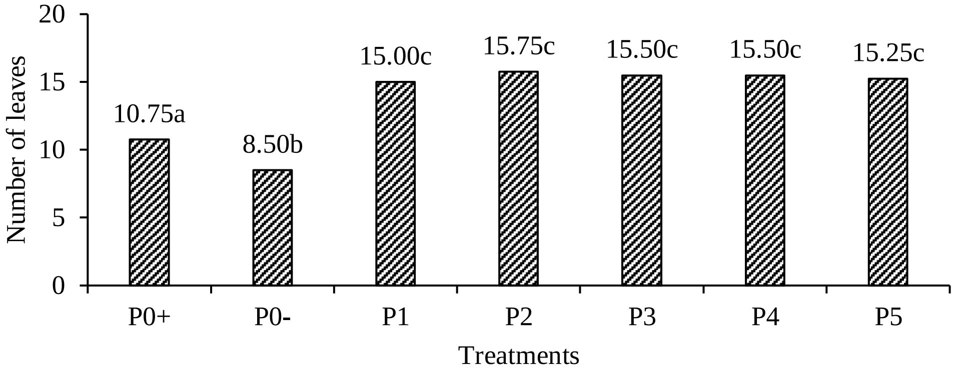

Figure 3. Effect of cajuput leaf waste fertilizer treatment on tomato' number of leaves at 6-weeks after planting (WAP). The numbers followed by the same letters in the same column show no significant difference based on Duncan's test at the 95% significance level

Flower Emergence Time and Number of Flowers

Flowers are an important parameter to observe, as it is indicating plant development in addition to vegetative growth. The time of flowering and the number of flowers on plants affect the likelihood of fruit formation (Table 3). The faster and the more flowers produced, the more likely the higher fruit produced.

Table 3. Average emergence time and number of flowers after treatments

Days after planting (DAP)	Treatments				
	P1	P2	P3	P4	P5
31	1.25 ^{ab}	2.25 ^{ab}	2.25 ^{ab}	2.75 ^{b}	3.50 ^{b}
41	8.00 ^{b}	9.50 ^{b}	8.75 ^{b}	10.50 ^{a}	9.50 ^{b}
51	22.75 ^{b}	25.75 ^{b}	21.75 ^{b}	22.50 ^{b}	25.50 ^{b}
61	31.00 ^{b}	29.75 ^{b}	33.00 ^{b}	33.50 ^{b}	34.50 ^{b}
71	30.50 ^{b}	28.50 ^{b}	31.50 ^{b}	32.50 ^{b}	36.50 ^{b}
81	28.00 ^{b}	28.25 ^{b}	31.50 ^{b}	30.50 ^{b}	34.00 ^{b}
89	29.00 ^{b}	26.75 ^{b}	28.50 ^{b}	29.75 ^{b}	32.75 ^{b}

Note: The numbers followed by the same letters in the same column show no significant difference based on Duncan's test at the 95% significance level

Fruit Weight, Fruit Size (Diameter x Length), and Harvest Time

h The fruit quality is an important element to be considered in tomato cultivation as it directly affects the economic level of crop yields. The quality of the fruit can be observed from the maturity of the tomatoes. The following table shows the results of fruit diameter, length, and weight as well as the fruit harvesting time affected by fertilizer treatments (Table 4).

Table 4. Tomato fruits' diameter, length, weight, and harvesting time affected by fertilizertreatment

Treatments	Fruit weight (g)	Fruit diameter (cm)	Fruit length (cm)	Number of fruits	Harvesting time (DAP)
P1	13.75 ^{b}	3.14 ^{b}	3.02 ^{b}	16.00 ^{b}	89
P2	23.00 ^{cd}	3.40 ^{cd}	3.49 ^{c}	12.00 ^{b}	89
P3	20.00 ^{c}	3.37 ^{c}	3.36 ^{c}	13.00 ^{b}	89
P4	26.25 ^{d}	3.60 ^{d}	3.86 ^{d}	18.00 ^{bc}	89
P5	14.25 ^{b}	3.01^{b}	2.88 ^{b}	20.00 ^{c}	89

Note: The numbers followed by the same letters in the same column show no significant difference based on Duncan's test at the 95% significance level. Days after planting (DAP)

DISCUSSION

Table 1 shows that C-organic in treated fertilizers P1, P2, P3, and P4 have met the standards of The Regulation of Minister of Agriculture (2011) No.70/Permentan/SR.140/10/2011. The C-organic component is essential as the organic matter contained in fertilizers as it is the basic ingredient used for soil structure improvement and plant growth. Organic content in agricultural waste is generally abundant. As observed in the treatment of 75% cajuput leaf waste fertilizer + 25% manure (P2) that has the highest organic matter content of 44.28%. There is a relationship between the total N content and the C content, where the higher the organic C, the higher the opportunity to provide nitrogen. This increase occurs due to microorganisms producing nitrogen and ammonia by decomposing organic matter (Nugroho, 2018). On the other hand, the P5 treatment (100% manure) had a very low C-organic content and far met the standard. This is influenced by the basic ingredients of fertilizers, in this case, organic materials derived from plant residues such as those contained in the fertilizer treatments P1, P2, P3, and P4 with higher C-organic content because there is cajuput leaf waste in it.

Based on the C/N ratio, the treatment of 100% cajuput leaf waste fertilizer (P1) and 100% manure (P5) was considered less than standard as the C/N ratio was below 15–25. The lack of C/N ratio in P1 treatment occurred allegedly due to the cajuput leaf secondary metabolites left resulting in less availability of decomposer agents, and less N produced. This is indicated by the slow composting process that occurs in 100% cajuput leaf waste which naturally takes up to 3–5 years. The low C/N ratio in the P5 treatment was thought to be due tothe lack of organic matter available so N production was limited. Afrilliana et al. (2017) explained that the value of the C/N ratio of fertilizer indicates the level of organic matter contained in it which determines whether the addition of the decomposition process is needed to produce N.

In contrast to N, the highest phosphorus content was obtained in the P4 treatment. The phosphorus element binds to the P_2O_5 present at the end of the decomposition process by microorganisms. Generally, the phosphorus content is directly proportional to the total nitrogen produced. As described by Hidayati et al. (2011), phosphorus will become phosphate after being released from nucleic acids and lecithin due to the decomposition processof nitrogen and carbon by microorganisms. This discrepancy is thought to be due to the contentof secondary metabolites in cajuput leaf waste that can inhibit the growth of microbial colonies, thereby slowing down decomposition (Nugroho, 2018).

Meanwhile, the highest potassium content was found in the P5 treatment of 0.8%. The presence of potassium is also influenced by the type of material composed. This causes P5 to have a higher K element than other treatments. Agustina (2015) explained that K_2O compounds are produced from the metabolic processes of microorganisms by utilizing free K^+ contained in the materials. The different types of substrates or fertilizer material affect the activity and ability of microorganisms to bind and store potassium in their cells which then be released backwhen degraded.

On another aspect, one of the indicators that determine the physical quality of fertilizer is color. In this study, all treatment fertilizers had the same color. Fertilizer treatment P1 was brown, P2 was blackish brown, while P3, P4, and P5 had black color. Color is one indicator of a well fermented fertilizer. This is based on the criteria of the National Standardization Agency (2004) and Agustina (2015) where the color of compost that is ready to use or ripe has a blackish-brown color.

The optimum pH is important to obtain suitable growing media conditions for plants. Based on Table 2, the pH of each treatment ranged from 6.2 to 6.6. This is in accordance with the provisions of The Regulation of Minister of Agriculture (2011) No.70/Permentan/SR.140/10/2011, which ranges from 4–8. The optimum pH indicates the maturity of the fertilizer, as the fertilizer pH fluctuates during the composting process and the pH will be nearly neutral when it ripes. The unsuitable pH condition of compost will interfere with the activity and survival of microorganisms to metabolize (Nugroho, 2018). The disturbed metabolic processes of microorganisms will affect the nutrient quality contained in the fertilizer.

Figure 1 shows the plant height in the treatment of 75% cajuput leaf waste fertilizer and 25% manure (P2) tends to be better than the average height of other treatments. This happened because the fertilizer composition of P2, in this case, the C and N were higher at 44.28% and 2.82% with a

C/N ratio of 15.70 (Table 1). Abdissa (2011) stated that nitrogen (N) is the most important macronutrient for plant growth and is needed in large quantities. Prasetya et al. (2009) stated that N is very important in the vegetative growth of plants so a lack of N in plants causes the growth is not optimal, characterized by stunted plant stems. The high C content of 44.28% in the P2 treatment causes high growth potential because organic C will form other compounds that are good for the soil. Prasetyo et al. (2014) explained that high organic C in fertilizers will cause the formation of carbon compounds such as CO_2, CO_3^{2-}, HCO_3, and CH_4. These compounds are important for plants' growth.

Based on Figure 2, the P2 treatment resulted in a higher stem diameter. This is because the P2 treatment fertilizer has the highest nitrogen (N) content of 2.82% among other fertilizer treatments. The availability of nitrogen in the growing media is correlated with organic mattersupplied to plants. Prastya et al. (2016) stated that the volume of photosynthate that plants produce is not only determined by the absorption of sunlight but also by the availability of raw materials in the ribosomes obtained from the absorption of nutrients in the soil. In addition, high nitrogen is a major factor for stem vegetative growth (Annisa & Gustia, 2017). The higher the nitrogen contained in compost, the higher the potential for the formation of the plant's vegetative organs.

The growth of plant stem diameter can indicate an increase in the wet weight and dry weight of the plant. This also indicates that the absorption of nutrients in plants is optimal so that theyare able to enlarge the stems. Prasetyo (2014) mentions that besides being necessary for plant height, nitrogen also plays a role in stem development. Nutrients provide a stimulus for the rateof photosynthesis to produce photosynthate which then affects the formation of stems.

Although not significantly different, Figure 3 shows that at 6 WAP the highest number of leaves were found in P2 treatment. This was due to higher levels of nitrogen in the P2 treatmentcompared to other treatments. Afrilliana et al. (2017) stated that high levels of N will stimulatemicroorganisms to make rapid changes to decompose organic matter in the media resulting in high availability of nutrients and faster absorption by plants.

Table 3 shows the observation on the appearance of flowers at 31 and 89 DAP which indicated that P5 treatment was more dominant. Compared to P5, there were also flowers with fewer numbers in other treatments, this was presumably because of the higher phosphorus content inthe P5 treatment. Annisa and Gustia (2017) explain that P or phosphorus plays a very importantrole in the early generative phase. Phosphorus initiates and accelerates flowering. In addition, phosphorus plays a role in strengthening the growth of young plants into mature plants, helps assimilation and respiration, and is able to stimulate root growth, especially in young plants. Meanwhile, all treatments had a number of flowers that were not significantly different, this was presumably because of the similar potassium content in each treatment. Mariani et al. (2017) stated that the K content in fertilizers can increase the number of flowers. Farastuti (2018) also mentions that potassium plays an important role in strengthening the flower tissueso it does not fall easily.

The time of appearance of these flowers is slower compared to what was described inthe Decree of The Regulation of Minister of Agriculture (1999) No. 882/Kpts/TP.240/7/1999 where flowers will appear on 25 DAP. The delay in entering the generative phase is thought to be due to the effect of branching in tomato plants. As reported by Wulansari et al. (2017), when the branch is not trimmed it will cause the fast growth of tomato plants and overproducing branches then leads to slower flower development. However, the flowering time in this study wasfaster than those reported by Pongoh (2011) where the tomato (PERMATA varieties) flowers appeared at 36.5 DAP at single spacing and 35.4 DAP at multiple spacings.

On the other hand, in the control treatment, up to 89 DAP, the tomato plants did not experience a generative phase which was indicated by no flowers appearing. This is presumably due to inadequate phosphorus and potassium elements in the media without fertilizer (P0 treatment). This is also thought to be due to the fact that these two elements are naturally low in the soil. Mariani et al. (2017) explained that in soil, the availability of potassium, in general, is low, between 0.001% to 4%.

Zebua et al. (2019) explained that the physiological maturity level of tomatoes can be reviewed by observing their physical characteristics, such as fruit length, fruit diameter, fruit weight, and fruit hardness or softness. The P5 treatment produced more fruit than other treatments ($P > 0.05$) (Table 4).

This number is directly proportional to the number of flowers produced because the more flowers appear, the higher number of fruits produced. The high number of fruits in the P5 treatment was due to higher potassium content in the P5 treatment than in the P2, P3, and P4 treatments. Farastuti (2018) explains that potassium plays a role in strengthening flower tissue so that flowers do not fall off easily. Therefore, the higher the potassium that plants can absorb, directly proportional to the potential for the number of fruits produced.

The potassium content of 0.8% in the P5 treatment was less compared to the P1 treatment. Although treatment P1 had higher potassium, this treatment had lower phosphorus than P5 and P4, resulting in a lower number of flower and fruit appearances. This is in accordance with the statement of Annisa and Gustia (2017) where phosphorus playsa role in accelerating flowering and increasing the percentage of flowers turning into fruit.

In addition, tomato plants in the P4 treatment had a larger fruit size and weight compared to the other treatments. This is due to the higher phosphorus content in the P4 treatment (1.63%) than the other treatments. Farastuti (2018) explained that the factor in planting media that affects fruit size is the availability of P. In the process of fruit enlargement, the availability of P in high quantity is needed. Elemental P is able to increase fruit development through enlargement of vesicles, obtained through the absorption of P in the form of phosphate ions dissolved in the soil. P4 treatment was able to produce fruit sizes (diameter; length) up to 3.60 cm; 3.86 cm with a weight of 26.25 g. ANOVA analysis showed that this treatment was significantly different from P1, P3, and P5 but was not significantly different from treatment P2. This means that treatment of 75% manure + 25% cajuput leaf waste fertilizer (P4) and 75% cajuput leaf waste fertilizer + 25% manure (P2) gave the same potential yield in terms of fruit size. Simanungkalit et al. (2013) explained that the availability of phosphorus and potassium is indeed an element that stimulates fruit formation.

However, the weight and size of fruit obtained in this study tended to be smaller than what was described in the Decree of The Regulation of Minister of Agriculture (1999) No. 882/Kpts/TP.240/7/1999 which ideally reaches 5.6 × 4.5 cm and weighs 50 g. However, these present results were greater than that of Pongoh (2011) which reported the diameter of the fruit produced by Permata variety tomatoes was 3.0 cm in single spacing and 3.1 cm in double spacing. This difference is thought to be due to the absence of additional cultivation treatment, such as branch trimming. Based on research by Wulansari et al. (2017), the trimming of tomato plant branches affects the size of the fruit. Treatment with branch trimming had a larger diameter or fruit size than tomatoes without branch trimming treatment.

Even though the results obtained were not significantly different, the P2 treatment (75% cajuput leaf waste and 25% chicken manure) is expected to reduce cajuput leaf waste significantly. Utilization of cajuput leaf waste as a side product from processing cajuput oil as organic fertilizer could have a positive impact. It is not only reduce the waste around the factory but also improve the quality of the environment to be pollution-free.

CONCLUSION

The nutrient composition of cajuput leaf waste fertilizer with a mixture of manure that has been composted consists of Organic C content of 20.08–44.28%, total N 1.76–2.82% with a C/N ratio of 11.21–18.71. However, cajuput leaf waste fertilizer only (P1) contained phosphorus and potassium of 1.25–1.63% and 0.29–0.61% respectively, which is smaller than chicken manure (P5). The application of fertilizer with a composition of 75% cajuput leaf waste fertilizer and 25% chicken manure (P2) showed the best results for growth and development, characterized by a plant height of 125.75 cm, stem diameter of 0.665 cm, number of leaves 15.75 leaves, and fruit size (diameter; length) 3.40 cm; 3.49 cm with a weight of 20 g. More investigation is required into the use of compost made from eucalyptus leaf waste for other plants, particularly vegetative vegetable crops, and efforts to speed up the composting process of eucalyptus leaf waste.

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