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KATA PENGANTAR

Salam,

Dengan mengucap syukur kepada Allah Tuhan Yang Maha Esa, kami terbitkan Agrointek edisi September 2021. Di tengah pandemi yang berkepanjangan ini, ilmuwan Indonesia masih tetap berkarya. Pada edisi kali ini 32 artikel hasil penelitian, yang terdiri dari 11 artikel dari bidang pengolahan pangan dan nutrisi, sistem manajemen, rantai pasok, dan pengendalian kualitas; 3 artikel tentang rekayasa pangan, dan 2 artikel tentang manajemen limbah. Para penulis berasal dari berbagai institusi pendidikan dan penelitian di Indonesia.

Kami mengucapkan terima kasih kepada para penulis dan penelaah yang telah bekerja keras untuk menyiapkan manuskrip hingga final. Kami juga berterimakasih kepada ibu dan bapak yang memberi kritik dan masukan berharga bagi Agrointek.

Untuk menyiapkan peringkat jurnal Agrointek di masa depan, kami mengharap kontribusi para peneliti untuk mengirimkan manuskrip dalam bahasa Inggris. Semoga kita akan mampu menerbitkan sendiri karya-karya unggul para ilmuwan Indonesia.

Selamat berkarya.

Salam hormat

Prof. Umi Purwandari

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ENHANCING THE QUALITY OF COMPOST FROM OIL PALM RESIDUE BY INOCULATING NITROGEN-FIXING BACTERIA: IMPACT ON *Brassica rapa V. Chinensis* GROWTH

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Azotobacter; decomposition; empty fruit bunch; solid waste

ABSTRACT

Oil palm empty fruit bunches (OPEFB) were by-products of the processing of oil palm mills. The addition of nitrogen-fixing microorganisms was carried out to improve nitrogen content in OPEFB compost and it can be used as a growing medium to increase the quality of vegetable crops. The aim of this study was to analyse the potential of empty fruit bunch composts enriched with Azotobacter for improving pak choi (Brassica rapa v. chinensis) growth. The process involved conversion of OPEFB by fortifying it with Azotobacter into value-added composts. Temperature, pH, conductivity, and nutrient characteristics of composts were analyzed during the composting process. The Completely Randomized Design with three replications was conducted to observe the potential of Azotobacter-fortified composts on pak choi growth. The growing media made in seven combinations, namely: F_0 (F0P1): 100% soil (control); T_1P_1: 30% OPEFB composts + 70% soil; T_1P_2: 50% OPEFB composts + 50% soil; T_1P_3: 70% OPEFB composts + 30% soil; T_2P_1: 30% OPEFB-Azo composts + 70% soil; T_2P_2: 50 % OPEFB-Azo composts + 50% soil; T_2P_3: 70 % OPEFB-Azo composts + 30% soil. Research revealed that the highest pH and conductivity values are 8.46 and 1.16 mS.cm^{-1}, which occured in Azotobacter assisted OPEFB composting. In the application of the compost as the growing media for pak choi, the morphological parameter shown significant effects. The Azotobacer assisted compost promoted significant increase in plant height (23,7 cm), root dry weight (2,84 g), shoot dry weight (2,39 g), root length (28,56 cm), leaf area (73,37 cm^2), and number of stomata (36,70 cm^{-1}).

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INTRODUCTION

Oil palm is considered the largest commodity in Indonesia. In 2018, palm oil production reached 3,22 million tonnes. The production of one ton of crude palm oil requires five tonnes of fresh fruit bunches. The process of converting fresh fruit bunches into crude palm oil produced solid wastes, such as oil palm empty fruit bunches (OPEFB), palm kernel shell (PKS), and mesocarp fibers (MF). According to (Stichnothe & Schuchardt, 2010) on average, 230 kg of empty fruit bunches is generated by one ton of fresh fruit bunches.

Oil palm empty fruit bunches are a lignocellulosic waste, which is the main by-product of the oil palm mill industries in Indonesia. This residue causes considerable environmental burdens. On the other hand, empty fruit bunches are a rich source of plant nutrients that can be applied as an organic fertilizer or as compost. Since the empty fruit bunches contain a high C/N ratio, about 44-55, that can decrease nitrogen availability in the soil, then use of the empty fruit bunches as compost is to reduce their carbon-to-nitrogen (C/N ratio). In the process of making compost, there is a possibility that the nutrient content of the compost produced is not as desired. (Kavitha, R., Subramanian, 2007) stated that compost produced from waste has a low nitrogen and phosphorus content. Nitrogen and phosphorus are important nutrients for plant growth and vegetative development. One way to improve the quality and nutrient content of compost is to inoculate microorganisms in compost. Microorganisms in growing media catalyze the essential transformation of major and minor elements. Among various growing media inhabitants, Azotobacter is a beneficial bacteria that can be inoculated with organic matter-rich compost to improve soil health (Singh et al., 2019). Azotobacter is a heterotrophic free-living N_2-fixing bacterium and produce phytohormone that has the benefit of increasing crop productivity. This bacterium can synthesize indoleacetic acid, gibberelins and B-vitamins which are growth-promoting substances. Therefore, the Azotobacter existence will generate positive response for plant growth (Afrilandha et al., 2018; Rodrigues et al., 2018). (Hashemniya et al., 2015; Kader et al., 2000) in his research stated that compost enriched with Azotobacter can increase plant height, leaf area index, and grain quality. (Van Oosten et al., 2018) mentioned specifically that *Azotobacter chroococcum* has been correlated with the secretion of auxins, cytokinins, and giberelic acid-like molecules which have established functions growth regulator in plant. It was also further stated that the addition of these bacteria could maintain soil fertility as indicated by the high content of organic carbon, available nitrogen, phosphorous and potassium.

Brassica rapa v. chinensis is an important vegetable crop containing vitamins, minerals and fibers. Organically grown vegetable crops have dry matter content. Application of organic amendments and biofertilizers can increase yields and quality of vegetables. (Kumar et al., 2015) stated that the performance of cabbage was recorded higher in some parameters such as P, K and minerals with biofertilizer (PSB + Azotobacter) treatment. Fortification of OPEFB compost with Azotobacter is essential for improving the nitrogen content. The compost added in the plant media can increase seedling growth when compared with their growth without compost application. Hence, the present study was undertaken to observe the quality of compost fortified by Azotobacter and to address the efficacy of Azotobacter-enriched emtpy fruit bunch compost on growth and quality of pak choi (*Brassica rapa v. chinensis*).

METHODS

This research was conducted at the experiment field located in Politeknik Kelapa Sawit Citra Widya Edukasi, Bekasi, West Java, Indonesia. The empty fruit bunches/oil palm empty fruit bunch (EFB/OPEFB) were collected from the PT Kertajaya, PTPN VIII, Malingping, Banten. The Azotobacter isolate was obtained commercially and multiplied in the Biology Laboratory at Politeknik Kelapa Sawit Citra Widya Edukasi, Bekasi.

Composting procedures

The shredded empty oil palm bunches were boiled in a container filled with water for 60 minutes. After that, the materials were removed and then put into a sack to reduce excessive water content in the OPEFB material. In composting the OPEFB, the shredded OPEFB were weighed and mixed with cow dung, then put into a composter. The composting process was done by inoculating Azotobacter. to a mixture of oil palm empty fruit bunches and cow dung. The composition of composting treatment consists of: (a). T1 was 50%

oil palm empty fruit bunches + 50% cow dung, and (b). T2 was 70% composition of oil palm empty fruit bunches + 28% cow dung + Azotobacter 2%. The composting process was carried out for three months.

Determination of physicochemical properties of composts

The Temperature, pH, and conductivity of the compost were monitored once a month for three months of composting process. The temperature was observed using the thermometer. The probe of the thermometer was inserted into the composting pile, and the reading was recorded until it was constant.

The pH was monitored using the pH meter to determine the acidity of the sample, and the conductivity of the compost was measured using the conductivity meter (EC meter) to determine the total concentration of ions in a sample. According to (Sulaeman et al., 2005), ten grams of sample from each treatment was taken and put in a bottle. After that, 50 ml of aquades was added, and the mixture was stirred for 30 minutes. The pH and the conductivity of the suspension were measured.

Plant materials and growing medium

Seedlings of pakchoi were grown in polyethylene bags 20 cm x 15 cm (height x width) containing a mixture of empty fruit bunches compost and sub-soil with the following treatments, namely F_0 (F0P1): 100% soil (control); T_1P_1: 30% OPEFB composts + 70% soil; T_1P_2: 50% OPEFB composts + 50% soil; T_1P_3: 70% OPEFB composts + 30% soil; T_2P_1: 30% OPEFB-Azo composts + 70% soil; T_2P_2: 50 % OPEFB-Azo composts + 50% soil; T_2P_3: 70 % OPEFB-Azo composts + 30% soil. Pak choi seedbed seedlings were placed in containers that have holes or pores to remove excess water in the seedling media. Seedling media used was a mixture of cow dung with soil in a ratio of 1: 1. Before sowing the seeds, the media was first watered so that the conditions were moist. After that, the seeds were spread on the media. Pakchoi seed treatment was done by watering for up to 7 days or having 2-3 leaves. Pak choi that has been sown was moved to the container that has been prepared. The planting media container had a height of 20 cm with a diameter of 15 cm. In the container made a hole with a distance of 2 cm at the bottom and sides. The container was placed in an area that has been cleaned with flat topography and is exposed to sufficient sunlight. Planting was done by taking the seeds from the seedling place carefully so that the roots of the plants were not broken. Watering during the nurturing time was done two times a day, in the morning and the evening. Weeds around the plants were picked manually, and no additional chemical fertilizer was applied. Pest control was done manually by picking pests or caterpillars found in plants. Consolidation was done on sloping plants. Harvesting was done by pulling plants up to the roots and done carefully to avoid breaking the roots, which were used to determine the biomass and root length.

Plant height (cm) and Number of leaves

Plant height measurements were carried out on all samples, from the base of the stem to the highest leaf tip. Observation of the number of leaves was done by counting the leaves of Pak choi plants that have opened perfectly. Observation of both parameters was done once a week.

Leaf area, Number of stomata, Root length, Biomass.

Observation of the stomata was carried out using transparent nail polish solution applied on the lower leaf surface of the leaf. After drying, the clear cellophane tape was affixed to the nail polished leaf and then removed. The stomata sample, which stuck in the cellophane tape, were placed on the microscope slide, and then the calculation of the number of stomata was examined using CX22 LED microscope with a magnification of 400 X. Root length measurements were carried out using a ruler at the end of the experiment. Wet and dry biomass weights of the shoot and root were measured at the end of the experiment. measure the dry weight, the shoot and root were dried in the oven at $80^{O}C$ for 48 hours and weighed using the OHAUS digital scale.

Chlorophyll content and Nutrient analysis

Fresh tissue (1 g) was sampled from the fully expanded leaf and extracted with 90% acetone and TRIS HCl (Almeida et al., 2016; Kaya & Higgs, 2003). The results were measured using a UV/VIS Spectrophotometer. The shredded empty fruit bunch from the composting pile was collected for nutrient content analysis at the end of the study. The samples were collected from each treatment, and the nutrient content analysis was done at the Test Laboratory of the Agronomy and Horticulture Department in IPB University, Bogor. The parameters of the nutrient content included total nitrogen (N), phosphorous (P_2O_5), potassium (K_2O), total carbon (C), and carbon to nitrogen ratio (C/N).

Experimental design and data analysis

The experiment of the application of *Azotobacter*-fortified OPEFB (OPEFB-Azo) compost in pak choi growth was carried out using the Completely Randomized Design with seven treatment combinations with three replications each. Data were analyzed using the analysis of variance, and significant treatment means were separated by Tukey - Honestly Significant Different (HSD) at $P < 0.05$, using STAR 2.0.1 (Statistical Tool for Agricultural Research).

RESULT AND DISCUSSION

Temperature, pH, conductivity, and nutrient profile of composts

Changes in compost temperature tend to increase in the first month of the composting process. (Sahwan, 2016) stated that increase in temperature during composting period can caused by microbial activity, which was microbial respiration. In this study, it was shown that the alteration of the composting temperature slightly increases in the first two months and tends to decrease afterward. The highest temperature increase occurred in the T2 treatment (70% OPEFB + 28% cow dung + Azotobacter sp. 2%). The initial temperature (28.71 ^{O}C) then increased in the second month of composting (30.4 ^{O}C). This slight increase might be attributed to the *Azotobacter sp*. but furthermore, the inoculant must be optimized as a decomposer that helps composting activities. The temperature of compost in the third month decreased. The temperature reduction was found in the T2 treatment (70% OPEFB + 28% cow dung + Azotobacter sp. 2%) with a value (26.5 ^{O}C). This is related to the activity of microorganisms that are getting less and less because the nutrient in the compost material has been reduced. Microorganisms need carbon as an energy source in their metabolic processes (Chen et al., 2011). Temperature concern in composting process stated by (Rahayu 2017) that the steps of the microorganism activities during composting are mesophilic and thermophilic phase. The mesophilic phase is when the microorganism was starting to decompose, and the thermophilic phase is when the microorganism in the highest decomposing activities, and in the thermophilic phase, the temperature will increase. The effect of two composting treatments on temperature can be seen in Figure 1(a).

The pH observed results showed that changes in pH occurred every month. The pH was highly increased in the second month of composting process, as can be seen in Figure 1(b). In the third month of composting, the pH for each treatment was relatively constant or stable, but the pH of T2 treatment (70% OPEFB + 28% cow dung + Azotobacter sp. 2%) with a value (8.46) was higher compared to T1 treatment. The increase in pH was caused by the activity of microorganisms that no longer make changes in the organic matter of carbon compounds into organic acids. In contrast, the decrease in pH value occurs because of the reduction reaction that binds oxygen. This process will increase the activity of microorganisms and produce acidity compounds, which can cause reducing pH (Sundberg et al., 2004). The pH range at the end of composting is 8.14 - 8.46. The pH value in this range is in the minimum pH range based on the minimum technical requirements of solid organic fertilizer, which is 4 - 9 (Permentan, 2011).

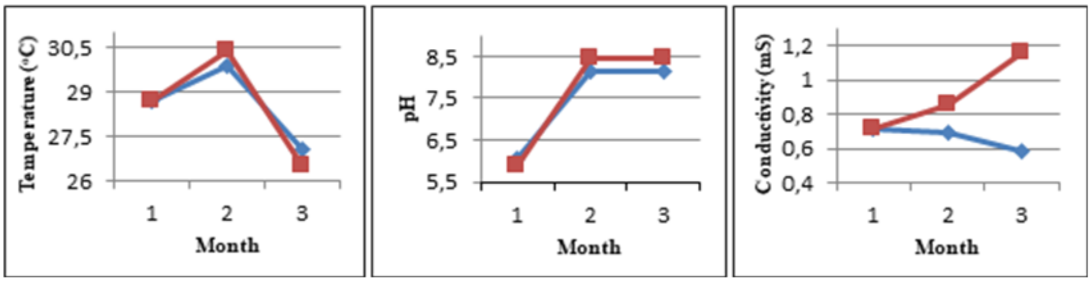

Figure 1 Effect of composting treatments: T1 (blue; 50% OPEFB + 50% cow dung) and T2 (red; 70% OPEFB + 28% cow dung + Azotobacter 2%) on the temperature, pH, and conductivity parameter of the compost. The graphs: left (a). temperature, centre (b). pH, and right (c). conductivity.

Table 1 Nutrient content of composts

Treatment	Parameter Pengamatan (%)				
	N-Tot	C-Org	C/N Ratio	P	K
OPEFB 50 % + cow dung 50 %	1.45	37.41	25.73	2.23	3.25
OPEFB 70 % + cow dung 28 % + *Azotobacter* 2 %	1.76	33.53	19.11	1.87	3.06

Table 2 The effect of oil palm empty fruit bunch (OPEFB) compost as growth media on plant height.

Treatment	Plant height				
	1	7	14	21	28
Soil 100% (F0P1)	3.5	6.5 e	12.0 g	14.0 g	18.3 d
OPEFB Composts 30% + Soil 70% (T1P1)	3.4	6.9 c	12.7 d	14.6 d	20.5 c
OPEFB Composts 50% + Soil 50% (T1P2)	3.5	6.7 d	12.4 f	14.5 e	20.6 c
OPEFB Composts 70% + Soil 30% (T1P3)	3.2	6.9 c	12.5 e	14.1 f	21.6 bc
OPEFB Composts+Azot. 30% + Soil 70% (T2P1)	3.3	7.9 b	13.4 c	15.6 c	23.4 a
OPEFB Composts+Azot. 50% + Soil 50% (T2P2)	4.4	7.9 b	13.6 b	15.8 a	23.7 a
OPEFB Composts+Azot. 70% + Soil 30% (T2P3)	3.3	8.4 a	13.7 a	15.7 b	22.7 ab

Note 1. The numbers followed by different letters show significantly different according to the 5% HSD Test.

The effect of two composting treatments on conductivity can be seen in Figure 1(c). The conductivity value at the end of the observation was highest in the T2 treatment (70% OPEFB + 28% cow dung + Azotobacter sp. 2%) with a value of (1.16 $mS.cm^{-1}$). In contrast, the conductivity value of T1 treatment was lower at the end of the observation (0.56 $mS.cm^{-1}$). In this study, the value of the conductivity of compost has increased in T1 and decreased in T2 during the composting period. The activity of Azotobacter in T2 was able to increase the conductivity value of OPEFB compost. (Karnchanawong & Nissaikla, 2014) Stated that the conductivity value is a good indicator because the increased conductivity value indicates the number of nutrients contained in compost.

In this research, the decomposition of EFB was in combination with the cow dung as well. The EFB is a lignocellulose material that has a low total N content. Therefore, it is major to apply additional organic matter to increase nutrients. As is shown in Figure 1, the combination can influence the quality of the compost. The addition of Azotobacter generated, the temperature, pH, and conductivity of the compost which slightly higher compared to the compost without inoculated Azotobacter. This was due to the high moisture content of the EFB. Empty fruit bunch, which was generated from the steam sterilization process in oil palm manufacturer, contains 50-60% of moisture content (Arbaain et al., 2019). According to (Mar et al., 2018), the moisture content is important to provide suitable metabolic activity of the microorganisms. Furthermore, it was mentioned that while moisture content during the composting process is high (65%), it will develop anaerobic conditions that suitable for the microorganism activities.

Nutrients profiles

The nutrient content of the research compost was shown in Table 1. Based on the analysis of nutrient content, compost of oil palm empty fruit bunches and cow dung compost and oil palm empty fruit bunch compost and cow dung enriched with Azotobacter showed the same pattern, which contained the highest K nutrients, which were then followed by P and N. However, the value of compost C / N ratio with the addition of *Azotobacter* is 19.11, lower when compared to compost without the addition of Azotobacter that has a C / N ratio value of 25.73. Nutrients N, P, and K are needed for plant growth. According to (Haryanti et al., 2014), nitrogen is the main nutrient for plant growth, which is generally very necessary for the formation or growth of vegetative parts of plants such as leaves, stems, and roots. Phosphorus is a part of cell nucleus, which is very important in cell division and for the development of meristems so that it can stimulate the growth of young plant roots (Hanudin et al., 2010). Potassium serves to strengthen the stiffness of the stem so that it reduces the risk of collapse (Haryanti et al., 2014).

Laboratory test results showed the nitrogen nutrient content in compost with the addition of Azotobacter higher than compost without the addition of Azotobacter, this happened because the nitrogen nutrient in the media is decomposed by Azotobacter. Azotobacter is a rhizobacteric species that has been known as a nitrogen-fixing biological agent, which converts free nitrogen into ammonium nitrate (Jnawali et al., 2015; Sethi & Adhikary, 2012). One of the compost maturity levels can be measured by the C / N ratio. From composting results approaching the C / N ratio of the soil, namely 70% OPEFB + cow dung 28% + Azotobacter 2% treatment. The mixture of soil and manure (1: 1) has higher levels of C and N and is just like the C / N ratio of the soil which indicates that this organic material is more mature and balanced (Madusari, 2015). Raw material with a high C / N ratio will be difficult to decompose, so it needs materials and activators that can reduce the C / N ratio. The speed of decomposition is influenced by the compounds contained in the organic material.

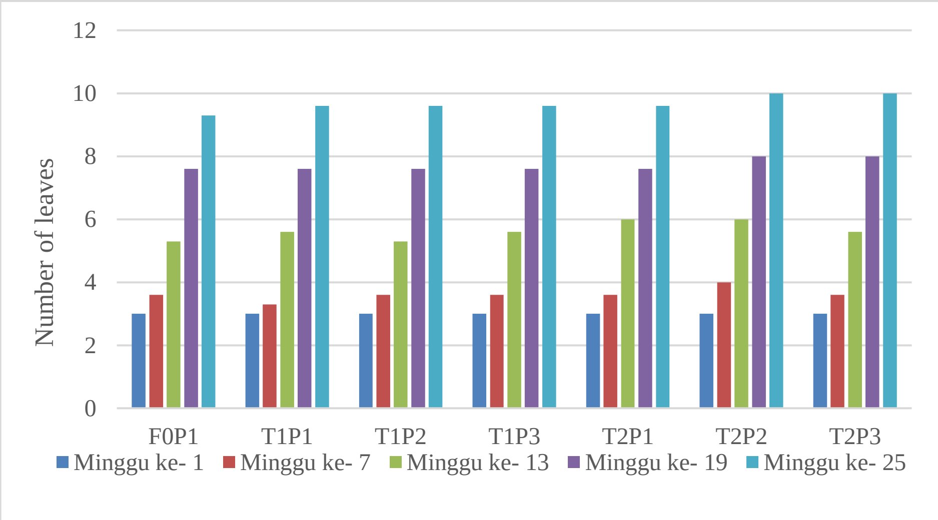

Figure 2 Effect of oil palm empty fruit bunch (OPEFB) compost as growth media on the number of leaves.

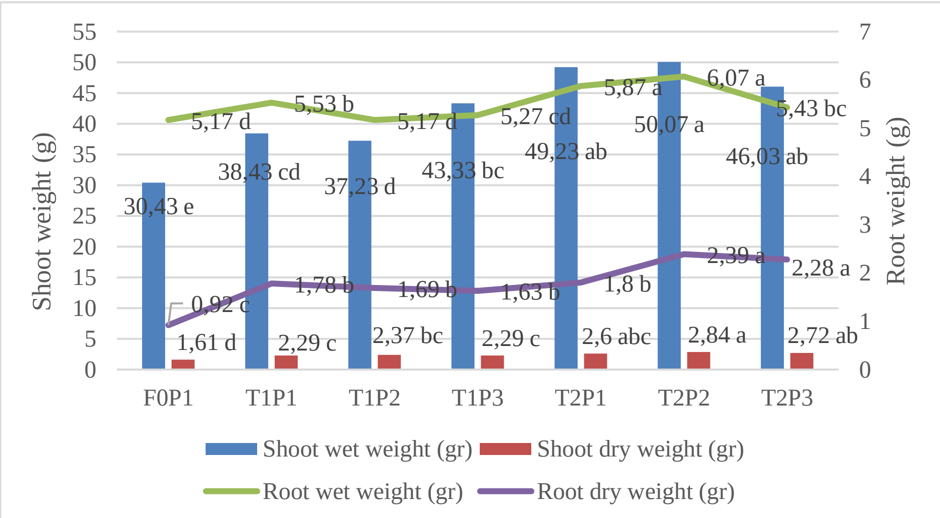

Figure 3 Effect of the various treatment of growing media of OPEFB composts on shoot wet weight, root wet weight, shoot dry weight, and root dry weight at fourth month after treatment. Different letters above the bars represent significant differences from a pair-wise comparison of all treatments according to Tukey-HSD at a significant level of α = 0.05.

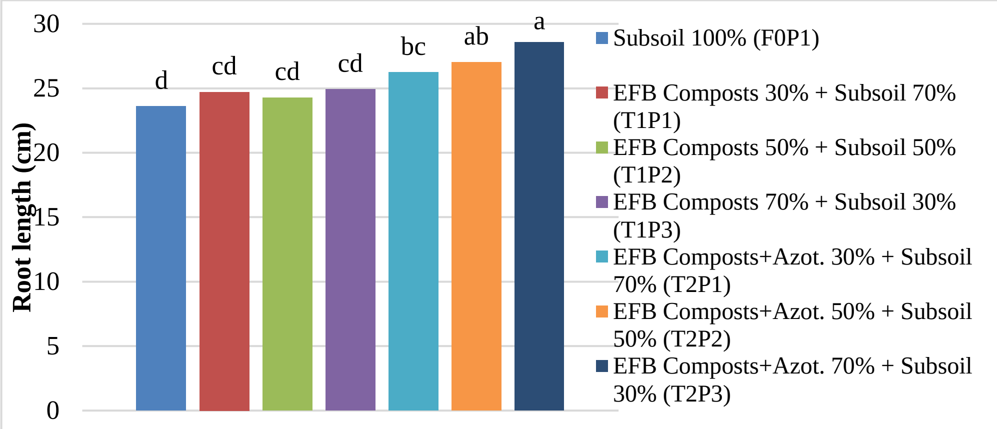

Figure 4 Effect of the various treatment of growing media of OPEFB composts root length after treatment. Different letters above the bars represent significant differences from a pair-wise comparison of all treatments according to Tukey-HSD at a significant level of α = 0.05.

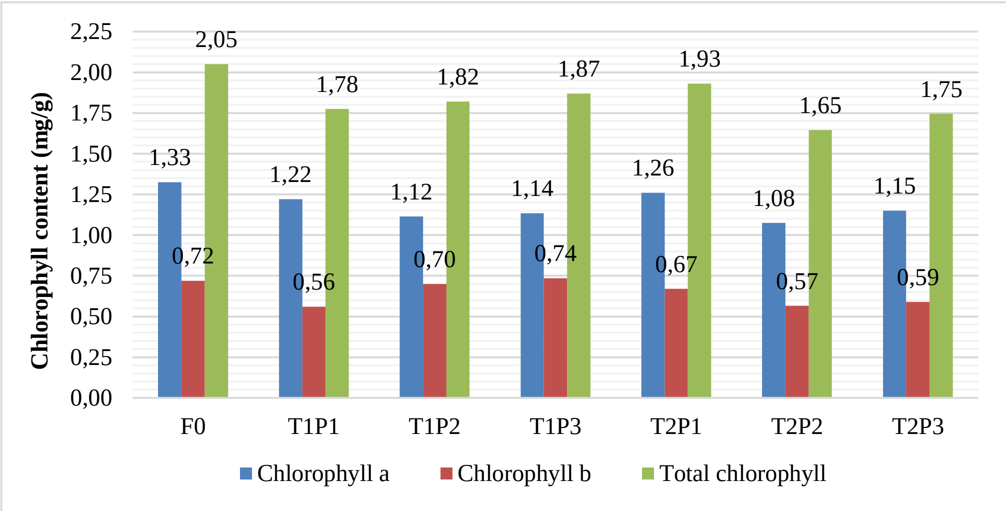

Figure 5 The content of chlorophyll a, chlorophyll b and total chlorophyll of Pak choi plants

The highest content of phosphorus and potassium in the analysis results is in the treatment without the addition of Azotobacter. The high nutrient level is due to the proportion of cow dung with the media as much as 50%. Processing cow dung which has high N, P, and K content as compost, can supply the nutrients needed by the soil and improve soil structure (Rahman et al., 2012). According to (Edi & Bobihoe, 2010) macronutrient requirements in the process of curly chili can be fulfilled by using cow compost which contains 0.40-2% N, 0.20-0.50% P, and 0.10-1.5%.

Plant height and Number of leaves

The effect of various treatments of growing media on the plant height and number of leaves can be seen in table 2 and figure 2. The highest plants based on table 2 that observed at the end of the experiment were found in the T2P2 treatment (OPEFB compost with Azotobacter 50% + Soil 50%) with a value (23.7 cm). Then the treatment with the lowest height plant was found in the treatment F0P1 (Soil 100%) with a value (18.3 cm). The treatment of compost growing media from oil palm empty fruit bunches with composting technique was added by Azotobacter can significantly affect the growth of pak choi.

The results showed that the composition of 50% OPEFB compost (fortified by *Azotobacter*) mixed with 50% soil as growing media significantly affected pak choi plant height. According to (Hanudin et al., 2010), in addition to being a source of nutrients, the provision of organic matter can improve the physical properties of the soil by reducing the weight of the soil volume, increasing the storage capacity of moisture, and adding the content of organic matter. Growth in the number of leaves showed constant growth from all treatments. This is because the calculation of the number of leaves starts from the leaves that have opened perfectly. Leaves which still budding and purplish in color, so the number of leaves has not been calculated (Madusari et al., 2020). According to (Edi & Bobihoe, 2010) that vegetative growth in plants is influenced by several factors such as environmental factors, nutrition, hormones, and plant genetics.

Root length, Shoot, and root wet weight Shoot and root dry weight, leaf area, and number of stomata

The effect of giving various growth media treatments on shoot wet weight, shoot dry weight, root wet weight, root dry weight, and pak choi root length can be seen in Figure 3 and Figure 4. Based on research data in the table shows the highest shoot wet weight is shown by the treatment of T2P2 (OPEFB Compost-Azotobacter. 50% + Soil 50%) with a value (50.07 gr). This is the same as the highest root wet weight found in the T2P2 treatment with a value (6.07 gr). This is in line with (Mahato & Neupane, 2018) which showed that the Azotobacter inoculation supporting to increase in plant height, stem girth, dry shoot weight, root length and width, and root weight on Maize. Furthermore, according to (Isroi, 2009), the wet and dry weight of plants are the outcome of glucose accumulation. This result is the main comes from photosynthesis activities. The physiological processes that happen in plants are promoted by efficient nutrient absorption from compost which can gain plant wet and dry weight. The difference in wet weight and dry weight of plants between treatments occurs because of the diverse growth of pak choi, so that the wet weight and dry weight of the seeds between treatments take effect. In addition, differences in wet weight and dry weight occur due to the factor of high sun intensity and the ability of seeds to absorb and store water differently. According to (Song Ai & Yunia Banyo, 2011), the shortage of water caused most of the leaf stomata are closed. Then, the carbon dioxide will enter, which then can reduce photosynthetic activity. This condition will affect the wet and dry weight of plants leading to be stunted.

In agriculture, a growth medium is a substance through which roots grow and extract water and nutrients, then the growth media plays an important role in producing a good crop. The average root length results showed that the use of T2P3 compost growth media (OPEFB Compost-Azotobacter 70% + Soil 30%) significantly affected root length. Based on the data presented in Table 4, the highest average root length with a value (28.56 cm) and the lowest was found in the F0P1 treatment (100% Soil) with a value (23.59 cm).

The influence of compost as a planting medium significantly influences the length of the roots, the shoot and root dry weight of pak choi, this is presumably because the media grows loose so that water and air easily enter and are stored in the planting media so that it can stimulate the growth of plant roots. In line with the statement of (Azlansyah et al., 2014), which stated that if plant roots develop well, then it will increase the nutrient absorption, and optimum growth and development of the plants can be achieved. This is in line with the (Ewusi-Mensah et al., 2020), which suggested that Azotobacter inoculated compost found increasing crop yield.

Table 3 Effect of giving various treatments of OPEFB compost growth media on leaf area and stomata count.

Treatment	Leaf Area (cm^2)	Number of Stomata $(mm^2)^{-1}$
Soil 100% (F0P1)	47.30 c	22.63 e
OPEFB Composts 30% + Soil 70% (T1P1)	62.43 b	25.57 d
OPEFB Composts 50% + Soil 50% (T1P2)	62.87 b	26.90 d
OPEFB Composts 70% + Soil 30% (T1P3)	62.43 b	29.47 c
OPEFB Composts+Azot. 30% + Soil 70% (T2P1)	72.63 a	34.43 b
OPEFB Composts+Azot. 50% + Soil 50% (T2P2)	73.37 a	36.70 a
OPEFB Composts+Azot. 70% + Soil 30% (T2P3)	72.67 a	32.87 b

Note 2. Different letters above the bars represent significant differences from a pair-wise comparison of all treatments according to Tukey-HSD at a significant level of $\alpha = 0.05$.

Provision of treatment of leaf area and number of stomata can be seen in Table 3. The results of the average leaf area growth and the number of stomata were known to the use of T2P2 growth media (OPEFB Compost-Azotobacter 50% + Soil 50%) significantly influence the leaf area growth and stomata number, based on the data presented in Table 4, with their respective values leaf area (73.37 cm^2) and the number of stomata (36.70 $mm^{2.-1}$) respectively, then the lowest was in the F0P1 (Soil 100%) treatment with leaf area values (47.30 cm^2) and the number of stomata (22.63 $mm^{2.-1}$). This is in line with (Al-Khazrji et al., 2020) research that shows the high values of the leaf area were attained by nitrogen-fixing bacterial treatment more than uninoculant plant in Maize. This suggests that the improvement of the absorption is increasing, and the capability of the bacterial to result in growth hormone, for example, Oxins and Giberelin.

Based on leaf area data and the highest number of stomata was found in the T2P2 treatment sample with leaf area values (73.37 cm^2) and the number of stomata (36.70 $mm^{2.-1}$). The number of stomata is closely related to leaf area. From the results of research conducted, it is known that the more surface area of the leaf, the more the number of stomata in pak choi plants. (Song Ai & Yunia Banyo, 2011) mentioned that the existence of the stomata correlates with the leaf surface area because a wide leaf surface area has a higher number of stomata. Furthermore, the opening of the stomata will determine the effects on the leaf area. This is also related to the leaf water pressure, which increasing its water pressure can reduce the opening of the stomata and the carbon processing that led to reducing the carbohydrate production, which decreases on leaf area (A. Alfalahi et al., 2015; Al-Khazrji et al., 2020).

Chlorophyll content

Chlorophyll is a type of pigment whose role is to convert solar energy into chemical energy in the process of photosynthesis. Azotobacter-inoculated plant have a high relative water content which shows that the bacterial activity activates the uptake of osmolytes which may have contribution to maintain a water uptake for maintaining turgor pressure and photosynthesis activity (Van Oosten et al., 2018). Nitrogen is an element that is known to present in a chlorophyll pigment. This research showed that the treatment of giving Azotobacter-assisted compost in growing media did not have a significant effect on the parameters of chlorophyll a, chlorophyll b, and total chlorophyll (Figure 5). The highest amount of chlorophyll a, chlorophyll b and total chlorophyll is found in soil growing media with the value 1.33, 0.72, and 2.05 mg. g^{-1}, respectively. Meanwhile, the lowest number of chlorophylls has a different effect for each treatment. The lowest chlorophyll a, chlorophyll b and total chlorophyll values were found in the treatment of 50% soil + 50% compost of cow dung with the addition of Azotobacter which the values are 1.08, 0.57, and 1.65 mg. g^{-1}, respectively. Many studies have been explained and illustrate that Azotobacter is able to increase chlorophyll content in plants. (Afrilandha et al., 2018; Mahato & Neupane, 2018) explained that the availability of nitrogen elements used to estimate the status of the chlorophyll content. However, in this study, the role of Azotobacter applied through composting process is still not effective and efficient to increase chlorophyll content.

CONCLUSION

The inoculation of Azotobacter within the combination of 70% of OPEFB, 28% of cow dung tend to improve the nitrogen content in compost. Azotobacter assisted-compost attributes the pak choi growth significantly which is observed in most of the morphological parameters. Therefore, the study indicates that use of Azotobacter potentially a wise choice to valorize the solid waste biomass compost and support the pak choi from a growth point of view.

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