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Increasing Growth, Production and Nutrient Uptake of Pakcoy (*Brassica rapa* L) Plant on Peat Soil by Applying Polyvalent Cation Ameliorant Cu^{2+}, Fe^{3+}, Zn^{2+} and Palm Front Compost

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ABSTRACT

The development in Riau has led to converting agricultural land to non-agricultural use, impacting the cultivation of vegetable crops on peatlands that require intensive treatment to achieve maximum productivity. The research aims to assess the effects of ameliorants and oil palm frond compost application on the growth, production, and nutrient uptake of pakcoy plants (*Brassica rapa* L). The experiment utilized a Completely Randomized Factorial Design with 2 factors. The first factor involved ameliorants with 4 treatment levels: without ameliorant, Cu^{2+}, Fe^{3+}, and Zn^{2+}. The second factor included oil palm frond compost with 4 treatment levels: without compost, 12. 24. and 36 g/plant. Parameters observed were plant height, leaf count, fresh weight, dry weight, and nutrient uptake of N, P, and K. Results showed significant interaction effects between ameliorants and oil palm frond compost on plant height, leaf count, fresh weight, and nutrient uptake of N, P, and K, with the best treatment being Cu^{2+} ameliorant and 24 g/plant oil palm frond compost. The primary effect of ameliorants significantly influenced all observed parameters, with Cu^{2+} being the best treatment. The primary effect of oil palm frond compost significantly influenced all observed parameters, with 12 g/plant being the best treatment.

Keywords: *Ameliorant, Growth, Pakcoy, Palm Frond Compost, Production*

1. INTRODUCTION

The market demand for vegetables has now become quite commercially viable, in line with the increasing population and awareness of nutritional needs. The rising demand for vegetables, especially pakcoy, presents an opportunity for farmers, particularly in the Riau region, to cultivate and commercialize them. Economically and in terms of business, pakcoy has a higher selling price than vegetables like mustard greens.

Production data for mustard plants in the last 5 years are as follows: in 2018. namely 1.986 tons; in 2019. with a total production of 1.339 tons; in 2020. i.e., 1423 tons; in 2021. there was an increase in production; i.e., 1.673 tons, also experiencing an increase in 2022. namely 2.249 tons BPS, (2022). Although there is an increase in production from year to year, the need for mustard greens cannot be met, so to meet these needs, it is supplied from outside the region, one of which is West Sumatra; for this reason, it is necessary to increase production again to meet the needs of mustard greens.

The increasing development of Riau province impacts the conversion of agricultural land to non-agricultural land, so plant cultivation efforts lead to marginal land, which is poor in nutrients, namely peat land.

Indonesia is the fourth country after Canada, the Soviet Union, and the United States to have large peatland areas. The area of peat land in Indonesia is estimated at 14.95 million hectares spread across the islands of Sumatra, Kalimantan, and Papua and a small part in Sulawesi (Wahyunto et al. 2014)

The increasing conversion of fertile agricultural land on the island of Java, which has so far supplied 60% of Indonesia's food needs, means that fertile agricultural land is becoming limited, making more people aware of how essential peatlands are for agricultural development is not an exaggeration to say that peatlands are Indonesia's future food storage. Masganti (2013) in (Susilawati, et al. 2017)

The development of plant cultivation on peatlands faces the main obstacles, namely low soil fertility, low soil pH due to high organic acid content, and high cation exchange capacity (CEC) but low base saturation (KB) Manurung et al. (2017). However, With proper management, peat soil can be used as productive land. Efforts to overcome low soil fertility in peat soil can be made by adding ameliorant materials. Lubis et al. (2017) stated that ameliorant is a material that can increase soil fertility by improving physical and chemical conditions. The criteria for a good ameliorant for peatlands are having high base saturation (KB), significantly increasing the pH level, improving soil structure, having complete nutrient content, and repelling toxic compounds, especially organic acids. The ameliorant materials that can be used are polyvalent cations such as Cu^{2+}, Zn^{2+}, and Fe^{2+}.

Research by Kustiawan et al. (2022) shows that the main effect of ameliorant is real on all parameters observed in green beans. The best treatment is Cu2+ ameliorant. Likewise, from the results of this research, the application of Cu^{2+} ameliorant is a better treatment than other ameliorants.

In addition to providing ameliorant materials, when using peat soil for cultivating plants, it is necessary to add organic materials such as compost. Compost is hoped to improve peat soil through decomposition to produce the macro and micro nutrients plants need to grow and develop as expected.

The research results of Aulia et al. (2022) show that the best palm frond compost in physical analysis is a temperature of 290C, N 1.49%, P total 0.55%, K total 0.71%, which meets SNI19-7030-standards—2004 compost quality.

Research by Sundari et al. (2014) showed that giving palm oil leaf midrib

compost with various decomposers to pakchoy plants gave non-significantly different results; in observations, the resulting fresh weight was 60.47 g/plant. There was a difference in the results when observing the fresh weight of the plants, whereas the results of this study showed that the fresh weight of the pakcoy plants reached 172.33 g/plant.

The research aims to determine the effects of ameliorants and oil palm frond compost on peat media growth, production, and nutrient uptake of pakcoy plants.

2. MATERIAL AND METHODS

This research was conducted in the experimental garden of the Faculty of Agriculture, Riau Islamic University, at coordinates 0.44736. 101.45732. for 3 months starting from November 2023 to January 2024.

The materials used in this research were Pakcoy var Nauli mustard seeds, ameliorant (Cu^{2+}, Fe^{3+}, Zn^{2+}), palm frond compost, Urea, TSP, KCl, peat soil, polybags, wood, nails, zinc plate, paint, raffia rope and so on. The tools used in this research were a hoe, sprinkler, measuring tape, scissors, hand sprayer, camera, digital scales, bucket, scoop, measuring cup, and writing utensils.

This research used a completely randomized factorial design (CRD), which consisted of 2 factors. The first factor was ameliorant (P), which consisted of 4 levels without ameliorant, Cu^{2+}, Fe^{3+}, and Zn^{2+}. The second factor is oil palm frond compost (K), which consists of 4 treatment levels, namely 0. 12. 24. and 36 g per plant. Thus, 16 treatment combinations were obtained, and each treatment combination was repeated 3 times so that there were 48 experimental units. Each replication consisted of 8 plants, and 6 were used as samples. The research implementation included land preparation, namely cleaning it from weeds and rubbish, leveling the land using a hoe to make it easier to arrange the polybags, and then filling 2 kg polybags. The soil used was sapric peat, taken from the Kubang Raya area, Siak Hulu District, Kampar Regency, where the peat depth is 50-100 cm. After completing the filling, the polybags were then arranged in each experimental unit with a distance of 20x30 cm and 50 cm between experimental units. Pakcoy seeds are sown 10 days before planting using rockwool media. Planting is carried out after the seedlings are 10 days old by moving the pak choy seeds from the nursery to polybags. One seed is planted in each polybag. Application of the ameliorant material is carried out three weeks before planting, given by mixing it with peat soil according to the treatment dose, namely CuSO4 3 g/polybag, FeSO4 2 g/polybag (5% maximum absorption), and ZnSO4 0.6 g/polybag. Application of palm frond compost is given 2 weeks before planting according to the dosage, namely without palm frond compost, 12. 24. and 36 g per plant by mixing with peat soil.

Plant maintenance includes applying essential fertilizer at the time of planting. The fertilizer used is Urea 0.6 g/polybag (100 kg/ha), TSP 0.6 g/polybag (100 kg/ha), and KCl 0.6 g/polybag (100 kg). /Ha). Fertilizer is applied by immersing it at 10 cm from the plant. Watering, weeding, pest and disease control. The parameters observed were plant height, number of leaves, wet weight, dry weight, and nutrient uptake of N, P and K. Data from the observations were analyzed statistically. If the F-count exceeds the F-table, proceed with the Honest Significant Difference Test (BNJ) at the 5% level.

3. RESULT AND DISCUSSION

3.1 Plant Height

The results of the variance analysis showed that both the combination and the main effect of providing ameliorant and palm frond compost were significant on the height of the pak choy plants. The average results of plant height observations after further

BNJ testing at the 5% level can be seen in Table 1.

Table 1 shows that the highest average plant height was obtained in treating Cu^{2+} ameliorant and 24 g oil palm frond compost, 25.67 cm. Ameliorant Cu^{2+} gives more effective results in improving peat soil and palm frond compost at 24 g, which is the right dose. The standard deviation value indicates the variation in individual data towards the average value. The small standard deviation values in this table (0.00 to 0.58) indicate that the plant height observation data is close to the average value.

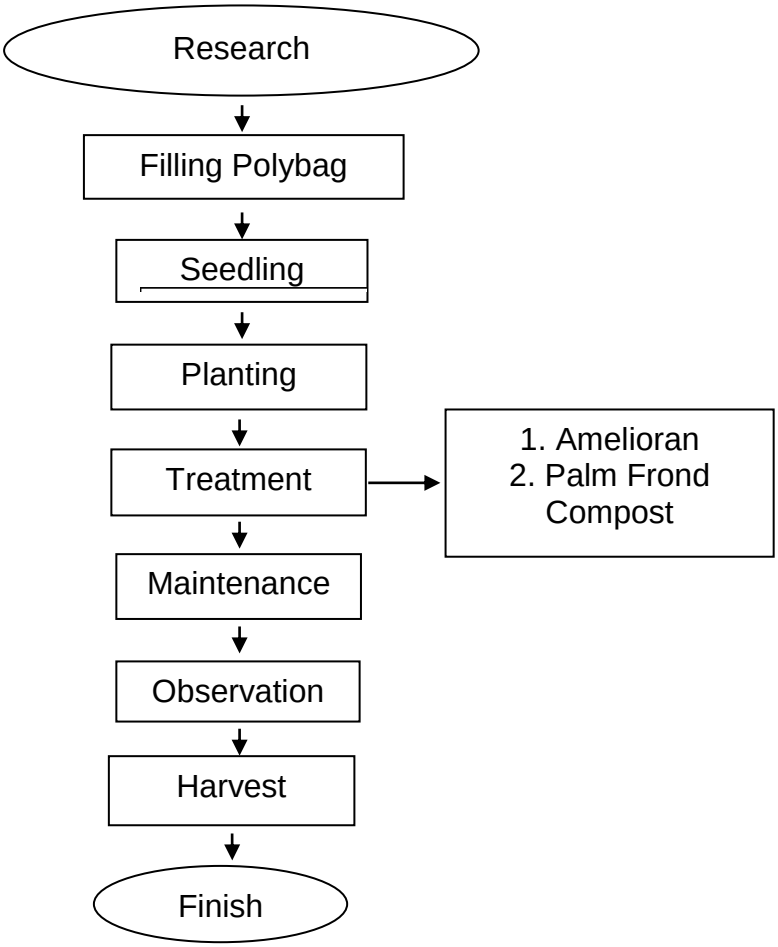

Figure1. Research Flow Diagram

The combination of giving ameliorant and palm frond compost gave a good response to pak choy plant height, where giving Cu^{2+} ameliorant combined with 24 g of palm frond compost/plant, was able to produce the highest plant height, namely 25.67 cm, and this was significantly different from all other treatment combinations. At the same time, the lowest pak choy plant height was produced in the treatment without ameliorant materials and oil palm frond compost, with a plant height of 15.33 cm.

The high pak choy plants produced by the combination of Cu^{2+} ameliorant treatment and oil palm frond compost are because administering Cu^{2+} ameliorant has been able to create better peat soil conditions, the Cu^{2+} ameliorant given can suppress the organic acids contained in peat soil so that they do not poison the plants then combining it with palm frond compost can further activate the microorganisms in the peat soil so that it can increase the decomposition and mineralization of the peat soil so that nutrients can be adequately available.

Ameliorant is a material that can increase soil fertility by improving physical and chemical conditions. The criteria for a good ameliorant for peatlands are high base saturation, complete nutrient content, and can neutralize toxic compounds for plants, especially organic acids high in peat soils. Ameliorants can be organic or inorganic materials. Providing ameliorant materials can also increase soil pH and alkalinities (Sasli, 2011).

Table 1. Pakcoy plant height (cm) with ameliorant treatment and oil palm frond compost.

ameliorant	oil palm frond compost (g/plant)				Mean
	0	12	24	36	
Without ameliorant	15.33±0.58^{j}	17.67±0.58^{i}	20.67±0.58^{def}	19.00±0.58^{ghi}	18.17^{d}
Cu^{2+}	20.67±0.58^{def}	21.67±0.58^{cde}	25.67±0.58^{a}	23.33±0.00^{b}	22.83^{a}
Fe^{3+}	18.67±0.58^{hi}	20.33±0.58^{def}	22.67±0.58^{bc}	22.33±0.58^{bc}	21.00^{b}
Zn^{2+}	18.33±0.58^{hi}	19.67±0.58^{fgh}	22.00±0.00^{bcd}	21.33±0.15^{cdɛ}	20.33^{c}
Mean	18.25^{d}	19.83^{c}	22.75^{a}	21.50^{b}	

Note: The numbers in the rows and columns followed by the same lowercase letters are not significantly different according to the BNJ follow-up test at the 5% level.

Zahrah (2010) stated that by administering ameliorant, it will be possible to produce new absorption sites that are capable of adsorbing (adsorption) and retaining N and P because complex compounds or chelates will be formed with Cu^{2+}, Zn^{2+}, Fe^{3+} cations which act as metal bridges between the molecules. Organic with N and P ions.

The low growth of pak choy plants without the application of ameliorant and palm frond compost was due to no improvement in the chemical properties of peat, where chelate compounds were not formed between Cu, Fe, and Zn cations and peat organic acids. This will disrupt root growth and plant nutrient absorption.

Palm frond compost is the same as other compost, where its application can positively affect the soil. Maryati et al. (2014) stated that TKKS compost can reduce H+ ions resulting from the hydrolysis of AL^{3+} and Fe^{3+}. Compost decomposition contributes simple organic compounds in the form of carboxyl and phenolic groups, which can bind Al and Fe to form complex bonds (chelates) so that they cannot contribute H+, causing the pH to increase with the addition of compost. This can be seen from the research results by applying Cu^{2+} ameliorant combined with 24 g of oil palm frond compost/plant, which can produce higher plant height.

3.2 Number of leaves

The variance analysis results showed that the combination and the main effect of ameliorant and oil palm frond compost were significant in the number of leaves. The average results of observing the number of leaves of Pakcoy plants after further testing with BNJ at the 5% level can be seen in Table 2.

The combination of ameliorant application and palm frond compost influenced the number of leaves of pak choy plants, where the application of Cu^{2+} ameliorant combined with 24 g of palm frond compost/plant produced the highest number of leaves, namely 18.83 pieces and was significantly different from all other treatment combinations, while the number The fewest pak choy plant leaves were produced in the treatment without ameliorant materials and palm frond compost with a total of 12.33 leaves.

Peat soil is soil that is poor in nutrients and contains high amounts of organic acids, so the ameliorant given can suppress the organic acids in the peat soil so that it does not poison plants.

Good soil conditions will support plant roots in developing and penetrating deeper into the soil so that plant roots can absorb nutrients as needed. Balancing this with oil palm frond compost can improve the condition of peat soil for the better.

Table 2. Number of leaves (strands) treated with ameliorant and oil palm frond compost.

ameliorant	oil palm frond compost (g/plant)				Mean
	0	12	24	36	
Without ameliorant	12.33±0.29^{f}	14.17±0.29^{e}	15.50±0.50^{cde}	15.17±0.29^{de}	14.29^{c}
Cu^{2+}	16.17±0.29^{bcd}	16.83±0.76^{bc}	18.83±0.29^{a}	17.17±0.58^{b}	17.25^{a}
Fe^{3+}	15.67±0.76^{b-e}	16.33±0.58^{bcd}	16.67±0.58^{bcd}	16.50±0.50^{bcd}	16.29^{b}
Zn^{2+}	15.33±0.76^{cde}	15.83±0.76^{bcd}	16.50±0.50^{bcd}	16.00±0.00^{bcd}	15.92^{b}
Mean	14.88^{c}	15.79^{b}	16.88^{a}	16.21^{b}	

Note: The numbers in the rows and columns followed by the same lowercase letters are not significantly different according to the BNJ follow-up test at the 5% level.

Ratmini (2012)) suggests that the bad influence of toxic organic acids on peat soil can be reduced by water management technology and the addition of materials that contain lots of polyvalent cations such as Fe, Al, Cu, and Zn.

This research also shows that applying Cu^{2+} ameliorant combined with palm frond compost at a dose of 24 g/plant has produced a greater number of pak choy plant leaves. It is suspected that the nutrients needed by the plants can be adequately met with this combination of treatments.

Increasing plant growth and yield is closely related to the uptake of N, P, and K elements. The higher N, P, and K uptake improves plant growth. This is in line with the opinion of Atmaja et al. (2017), who say that the macronutrients N, P, and K are essential nutrients for plants, which play a very important role in the plant growth process, which includes the processes of photosynthesis, respiration, energy transfer and storage, division. And cell enlargement and other processes.

The results of research by Syahminar et al. (2015) showed that the application of cow manure ameliorant to peat soil had an effect on the number of leaves of pakcoy plants at the ages of 7 and 14 HST, obtained at a rate of 2 tons/ha, while at the age of 21 HST, tankos was given at 8 tons/ha. Meanwhile, this study produced the highest number of leaves from oil palm frond compost, 24 g/plant (4 tons/ha).

The combination without ameliorant and compost of oil palm fronds produced the lowest number of leaves, 12.33 pieces. It is suspected that in this combination of treatments, there was no improvement in the chemical properties of the peat, where no chelate compounds were formed between Cu, Fe, and Zn cations with organic acids. In peat soil, this will affect the nutrient status in the soil, which will affect the number of leaves because the nutrients needed by the plant are not correctly fulfilled.

Abidin (2015) and Damayanti et al. (2019) state that the process of leaf formation cannot be separated from the role of nutrients such as nitrogen and phosphorus found in the soil medium and in conditions available to plants.

The response of the number of leaves to the application of oil palm frond compost with the application of various ameliorants (Cu^{2+}, Fe^{3+}, and Zn^{2+}) can be seen in Figure 2.

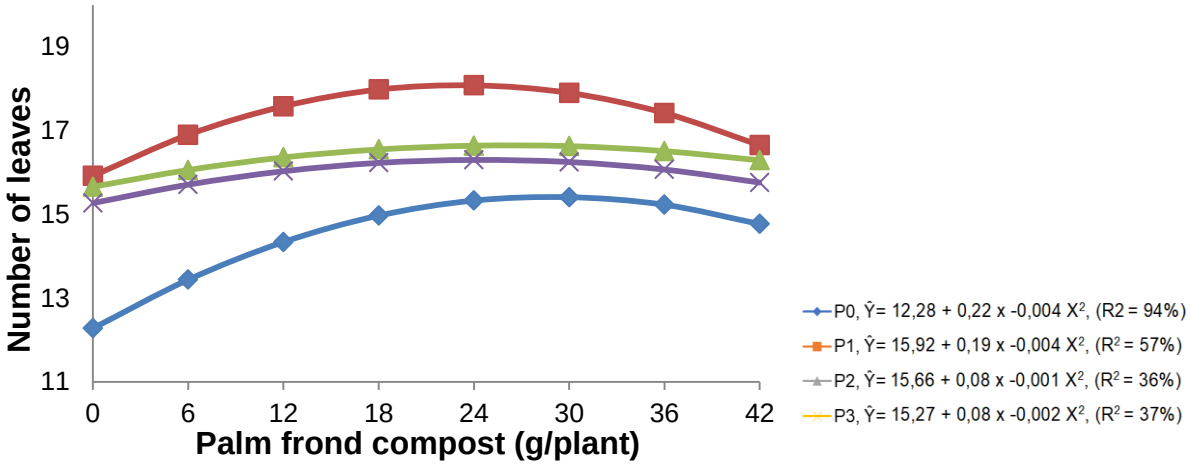

Figure 2. Graph of the response of the number of leaves to applying oil palm frond compost with various ameliorants (Cu^{2+}, Fe^{3+} and Zn^{2+})

From Figure 2 it can be explained that without the application of ameliorant material the coefficient of determination (R2) = 94%, meaning that the application of oil palm frond compost influenced 94% of the leaf number results. In contrast, with the application of the ameliorant Cu (P1), the coefficient of determination (R2) = 57 %, meaning that 57% of the growth in the number of leaves is influenced by the provision of palm frond compost, with the provision of Fe (P2) the coefficient of determination (R2) = 36%, meaning that 36% of the growth in the number of pakchoy leaves is influenced by the provision of oil palm frond compost, then by providing Zn (P3) produces a coefficient of determination (R2) = 37%, meaning that the application of oil palm frond compost influences 37% of the growth in the number of leaves.

The highest response to providing oil palm frond compost was found in the treatment without ameliorant, but it produced the least number of leaves. In contrast, the P2 treatment had the lowest response of pakchoy plants to oil palm frond compost, but the number of leaves produced was greater, this was because it was balanced by giving ameliorant so that peat soil can have a better influence on the growth of pakcoy plants thereby producing more leaves.

3.3 Gross Weight

After analysis of variance, the observations on the wet weight of pakchoy plants showed that both in combination and the main effect of providing ameliorant and oil palm frond compost had a real influence on the wet weight of pakcoy plants. The average results of observations of the wet weight of Pakcoy plants after further BNJ testing at the 5% level can be seen in Table 3.

Table 3 shows the average wet weight of the heaviest pak choy plants obtained from Cu^{2+} ameliorant + oil palm frond compost, 172.33 g. The standard deviation value ranges from 0.58 to 2.08. indicating that the variation in plant wet weight observation data is not far from the average value.

Ameliorant dan Palm frond compost treatment had a significant effect on the fresh weight of pak choy plants per plant, where the best treatment was the administration of Cu^{2+} ameliorant combined with 24 g of palm frond compost/plant with a wet weight of 172.33 g and was not significantly different from the administration of Cu^{2+} ameliorant combined with palm frond compost 36 g/plant, namely 169.67 g. In contrast, the control treatment combined treatments that produced the lowest wet weight, 146.33 g.

Table 3. Average wet weight (g) of pak choy mustard plants treated with ameliorant and palm frond compost.

Ameliorant	oil palm frond compost (g/plant)				Mean
	0	12	24	36	
Without ameliorant	146.33±1.55^{i}	150.67±1.55^{h}	154.33±1.55^{gh}	159.00±2.08^{fg}	152.58^{c}
Cu^{2+}	161.67±0.58^{c-f}	164.33±0.58^{cde}	172.33±2.52^{a}	169.67±1.53^{ab}	167.00^{a}
Fe^{3+}	158.67±1.15^{fg}	161.33±0.58^{def}	166.67±2.08^{bc}	163.33±0.58^{c-f}	162.50^{b}
Zn^{2+}	157.33±0.58^{fg}	159.67±2.08^{ef}	165.33±1.15^{bcd}	160.67±0.58^{def}	160.75^{b}
Mean	156.00 c	159.00 b	164.67 a	163.17 a	

Note: The numbers in the rows and columns followed by the same lowercase letters are not significantly different according to the BNJ follow-up test at the 5% level.

The high wet weight produced by combining Cu^{2+} with palm frond compost is because applying ameliorant and palm frond compost to peat soil has created better soil conditions. The Cu^{2+} ameliorant material provided can suppress acids. Organic, where free organic acids can be further suppressed so that they do not poison plants, namely by forming complex compounds that can reduce and suppress the harmful effects of phenolic and carboxylic acids so that plants can absorb nutrients well, thus plants can grow and develop well, then by providing balance with the provision of organic material, namely oil palm frond compost, it can increase the decomposition and mineralization process of the peat soil so that the nutrients needed by the bok choy plants can be more available.

If nutrients are met according to needs, the photosynthesis process in the plant body will take place well, thereby maximizing plant growth. Zivcak et al. (2014) if the status of photosynthesis in plants is low, it can reduce photo assimilation in plants, and the flow/transport of soluble sugars to the stem will also be reduced, thereby affecting plant growth and development.

Research by Aprianto et al. (2021) shows that of all the growth and yield parameters of pak choy plants, the combined dose of 4 t ha-1 dolomite ameliorant + 30 t ha-1 chicken manure has the highest effect on increasing average productivity of all treatments.

The results of research by Illa et al. (2017) showed that the application of goat manure compost had a real influence on all growth parameters, and the goat manure compost fertilizer concentration of 62.5 grams was the lowest concentration which was able to provide the best results on pakcoy plants.

Research by Syahminar et al. (2015) shows that applying 4 tons/ha of cow manure ameliorant to peat soil can increase the fresh weight yield of pak choy plants. In line with this research, applying Cu ameliorant combined with oil palm frond compost 24 g/plant (4 tons/ha) produced the heaviest wet weight of pak choy plants, 172.33 g. This shows that the application of ameliorant can improve the condition of the peat soil, providing the nutrients plants need.

The results of research by Zahrah (2020) showed that the interaction of ameliorant (Cu^{2+}, Fe^{3+} and Zn^{2+}) and palm frond compost was significant on the percentage of fruity pods, dry seed weight and root volume in green beans, with the best treatment being a combination of Cu^{2+} ameliorant and 24 g of palm frond compost. /plant.

The decrease in the weight of pak choy plants in the combination without ameliorant and palm frond compost indicates that in this combination of treatments, plant growth was hampered due to the failure to improve the condition

of the peat soil. Thus, the nutrients were unavailable, so the plants' nutrients were not maximally fulfilled. which ultimately affects the photosynthesis process. As the photosynthesis process decreases, the assimilated material produced also decreases.

Adetiya et al. (2017) stated that for plants to grow well, there needs to be a balance in the soil's nutrients according to the plant's needs. Plants will use nutrients to stimulate the photosynthesis process. The photosynthesis results will be translocated to all parts of the plant to stimulate the vegetative and generative development of the plant.

The response of wet weight results to applying oil palm frond compost with the application of various ameliorants (Cu^{2+}, Fe^{3+} and Zn^{2+}) can be seen in Figure 3.

From Figure 3 it can be explained that without the application of ameliorant material the coefficient of determination (R^2) = 92%, anti-92% of the wet weight yield of pak choy plants is influenced by the application of oil palm frond compost, then by providing the ameliorant Cu (P1) the coefficient of determination (R^2) = 67%, meaning that 67% of the wet weight of pakcoy plants produced is influenced by the provision of oil palm frond compost, with the provision of Fe (P2) the coefficient of determination (R2) = 72%, meaning that 72% of the wet weight of pakcoy plants is influenced by the application of frond compost oil palm. In comparison, the application of Zn (P3) produces a coefficient of determination (R2) = 64%, meaning that the application of oil palm frond compost influences 64% of the wet weight of the plants produced.

3.4 Dry Weight.

The observations of the dry weight of pak choy plants showed that the combination had no significant effect, but the primary influence of ameliorant and oil palm frond compost was significant on the dry weight of pak choy plants. The average dry weight observation results after further BNJ testing at the 5% level can be seen in Table 4.

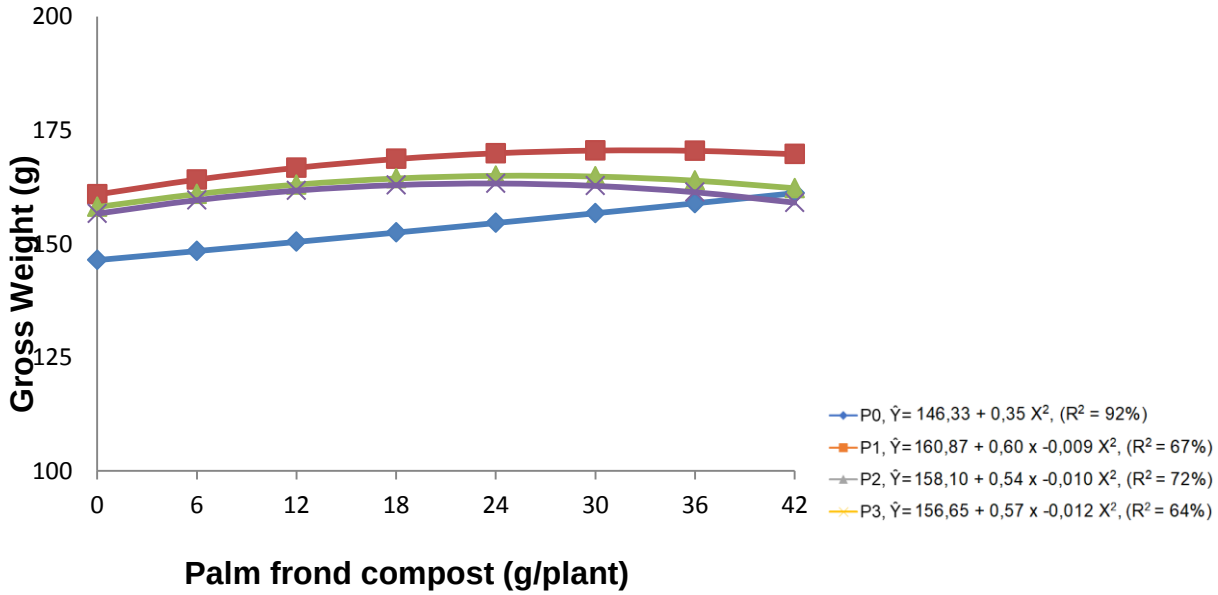

Figure 3. Graph of wet weight response to applying palm frond compost with various ameliorants (Cu^{2+}, $Fe^{3+,}$ and Zn^{2+}).

The data in Table 4 shows that the application of ameliorant influences the dry weight of pak choy plants. The application of Cu^{2+} ameliorant is the treatment that produces the highest plant dry weight, i.e.,8.93 g, which is significantly different from all other treatments, then followed by the application of Fe^{3+} ameliorant, namely 8.53 g. and was not significantly different

from giving Zn^{2+} ameliorant, namely 8.40 g and the lowest plant dry weight was produced by the control treatment, 7.88 g.

Providing ameliorant materials to peat soil can improve the physical and chemical conditions of peat soil, where free organic acids can be further suppressed so that they do not poison plants, namely by forming complex compounds that can reduce and suppress the bad effects of phenolic and carboxylic acids so that Plants can absorb nutrients optimally so that the photosynthesis process will run well and more assimilate will be produced, where the assimilate will be translocated to parts of the plant.

Table 4. Average dry weight (g) of pak choy plants treated with ameliorant and oil palm frond compost.

ameliorant	oil palm frond compost (g/plant)				Mean
	0	12	24	36	
Without ameliorant	6.63	7.63	8.93	8.33	7.88 c
Cu^{2+}	8.03	8.43	9.93	9.33	8.93 a
Fe^{3+}	7.70	8.17	9.30	8.97	8.53 b
Zn^{2+}	7.63	8.03	9.20	8.73	8.40 b
Mean	7.50 d	8.07 c	9.34 a	8.84 b	
	KK = 4.28%		BNJ P&K = 0.40		

Note: The numbers in the rows and columns followed by the same lowercase letters are not significantly different according to the BNJ follow-up test at the 5% level.

At the level of ameliorant application, the Cu^{2+} element is the treatment that produces the highest plant dry weight, and this is because the Cu^{2+} element has been able to provide a better response in improving the condition of peat soil, namely being more effective in suppressing toxic organic acids in peat soil. Thus, Plant roots can be more optimal in absorbing nutrients, so plant growth can also run well. Apart from acting as an ameliorant, the Cu^{2+} element can also be a source of nutrients for pakchoy plants. The micro element Cu also plays a role in starch formation and root development and acts as an activator of various enzymes.

Applying oil palm frond compost to peat soil can improve conditions for the better, supporting maximum growth of pakchoy plants and producing optimal dry weight. The results of this research can be seen. Where the application of oil palm frond compost at a dose of 24 g/plant is The treatment that produced the heaviest dry weight of pakchoy plants was 9.34 g, which was significantly different from the other treatments, while without palm frond compost, it produced the lowest dry weight, namely 7.50 g.

According to Waskito (2016), applying compost fertilizer can improve the physical properties of peat soil, such as water content, bulk density, load-bearing capacity, subsidence (subsidence) and irreversible drying, so plant absorption nutrients become more optimal. According to Mukhlis et al. (2011), organic materials can increase the pH value of the soil, because organic materials such as goat manure compost have the ability to chelate Al^{3+} lofam, so that the Al^{3+} hydrolysis reaction does not occur.

Syahminar et al (2015) research shows that giving 4 tons/ha of cow manure ameliorant to peat soil can increase the dry weight of pakcoy plants.

The decrease in the dry weight of pakchoy plants in the oil palm frond compost treatment of 12 g/polybag, it is suspected that at this treatment dose, the oil palm frond compost that was applied was not fully able to provide an excellent

response to the improvement in the condition of the peat soil, thereby affecting the availability of nutrients in the peat soil. thus affecting the dry weight of the pakchoy plant.

3.5 Nutrient uptake of N, P and K

The observations on the nutrient uptake of N, P, and K from pak choy plants showed that both in combination and the main effect of ameliorant and oil palm frond compost had a significant effect. The average results of observations of N, P, and K nutrient uptake after further BNJ testing at the 5% level can be seen in Table 5.

Table 5. Nutrient uptake of N, P, and K (mg/plant) of pak choy plants treated with ameliorant and oil palm frond compost

Ameliorant	N Nutrient Uptake (mg/plant) oil palm frond compost (g/plant)				Mean
	0	12	24	36	
Without Ameliorant	78±1.00n	119± 3.00m	214±3.00j	156±2.00 l	141.8 d
Cu^{2+}	219±3.00ij	297±1.00de	353±2.00a	338±1.00 b	301.8 a
Fe^{3+}	177±2.00k	238±3.00h	320±3.00 c	262±3.00 f	249.3 b
Zn^{2+}	148±3.00i	215±3.00j	292±2.00 e	242±3.46 gh	224.3 c
Mean	155.5 d	217.3 c	294.8 a	249.5 b	
Ameliorant	P Nutrient Uptake (mg/plant) oil palm frond compost (g/plant)				Mean
	0	12	24	36	
Without ameliorant	15±1.00 j	25 ± 2.00 i	54 ±1.00 gh	31±1.00 i	31.3 c
Cu^{2+}	58±2.00 fg	68±2.00 de	98±0.00 a	80±2.00 c	76.0 a
Fe^{3+}	54±2.00 gh	59±2.00 fg	91±2.00 ab	65±1.00 ef	67.3 b
Zn^{2+}	47±2.00 h	58±3.00 fg	84±2.00 bc	59±2.00 fg	62.0 b
Mean	43.5 d	52.5 c	81.8 a	58.8 b	
Ameliorant	K Nutrient Uptake (mg/plant) oil palm frond compost (g/plant)				Mean
	0	12	24	36	
Without ameliorant	39±1.00 h	69±1.00 g	91±1.00 cde	84±2.00 ef	70.8 d
Cu^{2+}	91±1.00 cde	101± 2.00 bc	125±3.00 a	110±2.00 b	106.8 a
Fe^{3+}	87±3.00 de	94±3.00 cde	109±1.00 b	96±2.00 cd	96.5 b
Zn^{2+}	68±3.00 g	73 ± 0.00 fg	112±2.00 b	93±2.65 cde	86.5 c
Rerata	71.3 d	84.3 c	109.3 a	95.8 b	

Note: The numbers in the rows and columns followed by the same lowercase letters are not significantly different according to the BNJ follow-up test at the 5% level.

The data in Table 5 shows that the highest plant nutrient uptake results were produced in Cu^{2+} ameliorant + 24 g of oil palm frond compost, both in N, P and K nutrient uptake with respective values of 353 mg, 98 mg and 125 mg. The standard deviation value for N uptake is 1.00 to 3.46. for P uptake is 1.00 to 3.00 and for K uptake is 0.00 to 3.0 in this data, showing that the variation in the observed data is very close to the average value..

From the plant nutrient uptake data (Table 5), it can be seen that there was an increase in plant N uptake up to the application of oil palm frond compost as much as 24 g/plant (4 tons/ha), with the addition of Cu, Fe and Zn ameliorants, as well as uptake. Plant P and K nutrients. However, by

administering 36 g of oil palm frond compost/plant, there was a decrease in plant nutrient uptake of N, P and K, both in the treatment without ameliorant and with the provision of ameliorant materials (Cu, Fe, Zn). Thus, it can be stated that excessive application of oil palm frond compost is also not good because it can reduce the growth and nutrient uptake of pak choy plants.

The highest plant nutrient uptake of N, P and K was found in the treatment of giving Cu^{2+} with oil palm frond compost as much as 24 g/plant, namely 353 respectively, 98. and 125 mg/plant, and the lowest nutrient uptake was found in the treatment without application of ameliorant materials and application of oil palm frond compost, namely 78 respectively; 15; and 39 mg/plant. More effective nutrient uptake through applying Cu^{2+} ameliorant combined with palm frond compost shows that Cu^{2+} ameliorant is more effective in reducing the content of free organic acids in peat soil than Fe^{3+} and Zn^{2+} ameliorant.

Lubis et al. (2017) stated that ameliorant is a material that can increase soil fertility by improving physical and chemical conditions. The criteria for a good ameliorant for peatlands are having high base saturation (KB), significantly increasing the pH level, improving soil structure, having complete nutrient content, and repelling toxic compounds, especially organic acids.

The administration of ameliorant will be able to produce new absorption sites that are capable of adsorbing (adsorption) and retaining N and P because complex compounds or chelates will be formed with Cu^{2+}, Zn^{2+}, Fe^{3+} cations, which act as metal bridges between organic molecules and N and P ions. Thus, the nutrients in the peat soil will be available and can be absorbed by the roots of the pak choy plant.

Plants' uptake of nutrients is greatly influenced by the levels and availability of nutrients in the soil. Mengel and Kirkby (2013) stated that N uptake by plants is primarily determined by the soil solution's or nutrient solution's N content in the planting medium.

Figure 4. Pakcoy plants in a combination of treatments of various ameliorants and each dose level of oil palm frond compost.

Organic fertilizer is an alternative that increases plant nutrient uptake availability, adequacy, and efficiency. Siregar (2010) and Hartatik et al. (2015). Applying oil palm frond compost can also improve the chemical properties of peat soil. Research results by Devinta et al. (2014) show that compost from corn cobs and goat manure can increase soil pH.

According to Waskito (2016), applying compost fertilizer can improve the physical properties of peat soil such as water content, bulk density, load-bearing capacity, subsidence (subsidence) and irreversible drying, so

plant absorption nutrients become more optimal. In line with this research, the application of oil palm frond compost at the right dose, namely 24 g/plant, pak choy plants are able to absorb higher N, P, and K nutrients compared to other treatments. Research by Zahrah (2010) showed that the interaction of ameliorant treatments (Cu^{2+}, Fe^{3+} and Zn^{2+}) on various lowland rice varieties significantly affected plant nutrient uptake of N, P, K. Furthermore, the research results of Maftu'ah et al. (2013) showed that the type and dose of ameliorant treatment had a real influence on the growth and uptake of NPK nutrients by sweet corn plants. Applying 20 tonnes/ha of bioameliorant with a formulation of 80% chicken manure + 20% dolomite provides the highest NPK nutrient uptake.

Providing P from both inorganic fertilizers and bioameliorant can increase N and P uptake in corn plants (Astiko, 2022). Susana et al. (2024) research results show that applying red mud and bokashi vegetable waste to peat soil can increase pH, base saturation, and availability of P, Ca, Mg, K, and Na nutrients. The absorption of N, P, and K nutrients is relatively the same between treatment combinations; the absorption of N elements is greatest followed by K and P elements. Applying 18 tons/ha of red mud and 15 tons/ha of vegetable waste bokashi is an effective dose for the growth and yield of white radish on peat soil.

4. CONCLUSION

The combination of ameliorant and palm frond compost was significant for plant height, number of leaves, fresh weight, and N, P, and K nutrient content. The best treatment was a combination of Cu^{2+} ameliorant and 24 g of palm frond compost per plant. The main effect of real ameliorant on all observation parameters is that the best treatment is the application of Cu^{2+} ameliorant. The main effect of palm frond compost was significant on all observed parameters, and the best treatment was applying 24 g of palm frond compost per plant.

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