



Effect of Bicomat and Tithonia Compost on Bok Choi (*Brassica rapa* L.) Productivity in Two Soil Types

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Abstract

The potential of former C-excavation mining land differs significantly from agricultural soil in terms of productivity and nutrient availability. Ecosystem restoration and soil productivity enhancement in marginal lands are necessary to improve crop productivity. This study aims to evaluate the effectiveness of biochar-coated humate (Bicomat) and Tithonia compost fertilizer on the growth and yield of bok choy (*Brassica rapa* L.) in two different soil types. The research was conducted from October to December 2024. The study employed a Randomized Block Design (RBD) with a non-factorial approach, consisting of three replications and eight treatments. Observation of growth parameters included plant height (4 Weeks after transplanting/WAP), root length (4 WAP), number of leaves (1-4 WAP), at the time of harvest wet weight and dry weight were observed. The data that has been obtained from the observation results then will be tested using the analysis of variance (ANOVA) further test of Tuckey HSD with 5% significance. Result showed the addition of Bicomat and Tithonia Compost showed differences in plant height 4 MST, number of leaves 4 MST, fresh -dry weight of bok choy plants. The S2T2B2 (Soil 2 + 300 g Tithonia Compost + Bicomat 20 t/ha) treatments more optimal in increasing plant height 4 MST, number of leaves 4 MST, dry weight of mustard plants on post C-excavation mining land. The S1T1B2 (Soil 1 + 200 g Tithonia Compost + Bicomat 20 t/ha) treatment was optimal in increasing plant height 4 MST, number of leaves 4 MST, dry weight of mustard plants on agricultural land.

Keywords: Bicomat; Bok Choi; C-Excavation Mining Land; Tithonia; Plant Productivity.

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INTRODUCTION

Indonesia is a country rich in natural resources, including mining lands that are explored to meet human needs. One of the mining activities utilized is C-excavation mining, which involves the extraction of non-strategic mineral resources (Munir & Setyowati, 2017). C-excavation mining refers to the extraction of various materials such as sand, gravel, stone, clay, and backfill soil. The soil from these mining sites tends to have low water retention capacity, making it unable to hold water for extended periods. It is also nutrient-deficient and highly susceptible to erosion. These conditions render post-mining C-excavation soil suboptimal for agricultural use (Ginting et al., 2018).

Indonesia possesses substantial natural resource potential, including sand mining and other C-category excavations. The rapid development in Indonesia has significantly increased the demand for construction materials. One of the primary sources of these raw materials comes from C-category mineral resources, particularly sand and stone, which are essential components in various infrastructure and construction projects (Pratama & Surur, 2021).

Soils classified under C-excavation mining typically exhibit extremely low nutrient content due to the removal of the topsoil layer, which serves as the primary source of nutrients for plants. The addition of organic amendments such as compost, biochar-based soil conditioners, and biofertilizers is expected to improve soil quality and support healthier plant growth. This approach also aims to enhance soil structure and stimulate microbial activity, ultimately contributing to overall soil fertility improvement (Antonius et al., 2015).

Biochar is a highly porous solid material obtained through the pyrolysis process. It is often referred to as bio-charcoal, distinguishing it from conventional charcoal, which is primarily used as fuel. Biochar contains stable organic carbon that is resistant to decomposition, has a porous texture, a smooth surface, and exhibits slightly alkaline properties (Simanjuntak et al., 2024). The characteristics of rice husk biochar include a pH of 8.7, organic carbon content of 24.4%, nitrogen (1.47%), phosphorus (0.44%), and potassium (0.88%) (Iskandar & Fitri, 2018). Hamzah et al. (2022) demonstrated that the application of biochar coated with humic acid (bicomat—biochar-coated humate) has significant potential in enhancing the growth of spinach, water spinach, and mustard greens.

Compost fertilizer serves a diverse and essential role in supporting plant growth and improving soil quality. One of its primary benefits is providing a complete range of nutrients, including macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), as well as micronutrients like iron (Fe), manganese (Mn), zinc (Zn), and copper (Cu). These nutrients play a crucial role in plant physiological processes such as photosynthesis, tissue formation, and flower production (Ginting et al., 2024). Additionally, green manure, such as *Tithonia diversifolia*, contributes to soil fertility enhancement. *Tithonia* is rich in nitrogen and phosphorus and improves soil structure by increasing organic matter content and cation exchange capacity (CEC). According to Wahyudi (Trisna et al., 2022), the application of green manure from *Tithonia* significantly enhances plant growth and crop yield by increasing nutrient availability and stimulating soil microbial activity.

The potential of post-mining C-excavation land differs significantly from agricultural land in terms of productivity and nutrient availability. Ecosystem restoration and increased soil productivity on marginal land are needed to increase crop productivity. Research comparing the productivity of post-mining C-excavation land with agricultural land due to the addition of biochar and tithonia compost as soil amendments is still limited. This study aims to evaluate the effectiveness of biochar-coated humate (Bicomat) and *Tithonia* compost fertilizer on the growth and yield of bok choy (*Brassica rapa* L.) in two different soil types.

METHODS

The research was conducted from October to December 2024 at the Greenhouse of Science Technopark (STP), Tribhuwana Tunggal University (Unitri), Malang, East Java, with sample analysis carried out at the Soil and Agronomy Laboratory. The materials used in this study included former C-excavation mining soil, collected from Trail Babat Alas, Krajan, Ketindan, Lawang District, Malang Regency, East Java, at coordinates Lat/ -7.833473°, Long. 112.681558°, with a tillage depth of 10 cm. The second type of soil was agricultural soil obtained from STP Unitri at 20 cm depth. The study utilized bok choy (*Brassica rapa* L.) seedlings, *Tithonia diversifolia* compost fertilizer produced by the Soil and Agronomy Laboratory Unitri, and biochar-coated humate (Bicomat) formulated by Hamzah et al. (2022). The chemical properties of the experimental materials are presented in Table 1.

Table 1. Characteristics of The Soil Chemical Properties of Research Treatment Materials

Chemical Properties	Agriculture Soil	Excavated Land C-Category soil*	Tithonia Diversifolia Compost	Bicomat**
pH	4.88	5.66	8.7	6.9
Total N (%)	0,8	0.18	1.47	0.68
Total-P (ppm)	660	0.2	4400	7000
Total K (ppm)	1190	0.07	8300	4000
C-Organic (%)	2.56	0.75	24.4	7.69

Source: * Dea et al., 2024, ** Hamzah et al, 2022

The study employed a Randomized Block Design (RBD) with a non-factorial approach, consisting of three replications and eight treatments. The details of the treatments are presented in Table 2. Agricultural land and Excavated Land C-Category soil are drained and filtered through a 2 mm sieve, weighed as much as 4 kg and then put into a polybag. *Tithonia* and bicomat compost are mixed into the soil then given water and kept moist for 1 week. Bok choy seeds of the new green variety are sown for 2 weeks before transplanting. At the time of transplanting, basic fertilizers of 150 Kg/ha N, 150 Kg/ha P₂O₅, and 100 Kg/ha K₂O were applied.

Tabel 2. Description of Research Treatment

No.	Treatment	Description
1	SC1	Soil Control 1 (Agriculture Soil)
2	SC2	Soil Control 2(Excavated Land C-Category soil)
3	S1T1B1	Soil 1 + 200 g <i>Tithonia</i> Compost + Bicomat 10t/ha
4	S1T1B2	Soil 1 + 200 g <i>Tithonia</i> Compost + Bicomat 20 t/ha
5	S1T2B2	Soil 1 + 300 g <i>Tithonia</i> Compost + Bicomat 20 t/ha
6	S2T1B1	Soil 2 + 200 g <i>Tithonia</i> Compost + Bicomat 10 t/ha
7	S2T1B2	Soil 2 + 200 g <i>Tithonia</i> Compost + Bicomat 20 t/ha
8	S2T2B2	Soil 2 + 300 g <i>Tithonia</i> Compost + Bicomat 20 t/ha

Observation of growth parameters included plant height (4 Weeks after transplanting/WAP), root length (4 WAP), number of leaves (1-4 WAP), at the time of harvest (4 WAP) wet and dry weight were observed. The data that has been obtained from the observation results then will be tested using the analysis of variance (ANOVA) further test of Tukey HSD with 5% significance.

RESULTS AND DISCUSSION

Plant height 4 WAP

The observation results show a difference in plant height due to the combination treatment of bicomat-tithonia compost 4 weeks after transplanting (p: 0.000998). Treatment S2T2B2

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exhibited the highest growth (35 cm) compared to other treatments, while Treatment S1T1B1 showed the lowest result among the treatments (19.14 cm). Both control treatments, whether agricultural soil (CS1) or ex-mining soil (CS2), demonstrated relatively lower plant heights compared to some of the other treatments (Figure 1).

Plant height serves as an indicator of plant growth, evaluates the effectiveness of inputs, determines the relationship between productivity and plant biomass, and acts as an indicator of plant stress. Observation results show a significant difference due to the combination treatment of bicomat and tithonia compost fertilizer on bok choi plant height 4 weeks after planting on two different types of soil. Figure 1 shows that ex-mining soil (CS2) results in growth almost equivalent to agricultural soil (CS1). However, when a combination of tithonia compost fertilizer and bicomat is added, the results are better than agricultural soil. Treatment S1T1B1 has the lowest growth, likely due to the fertilizer dose being too small to improve soil conditions sufficiently.

These indicated that the addition of specific organic amendments has the potential to improve soil quality and significantly support plant growth. The increase in bok choi height over four weeks after planting (WAP) was closely associated with the application of soil amendments. Biochar influences physical and chemical soil properties, contributing to enhanced soil fertility and the restoration of degraded soils (Hamzah et al., 2017). Humic acid acts as a ligand capable of binding nitrogen and forming complexes that temporarily retain nutrients in the soil, releasing them when plants require them (Hermanto et al., 2013).

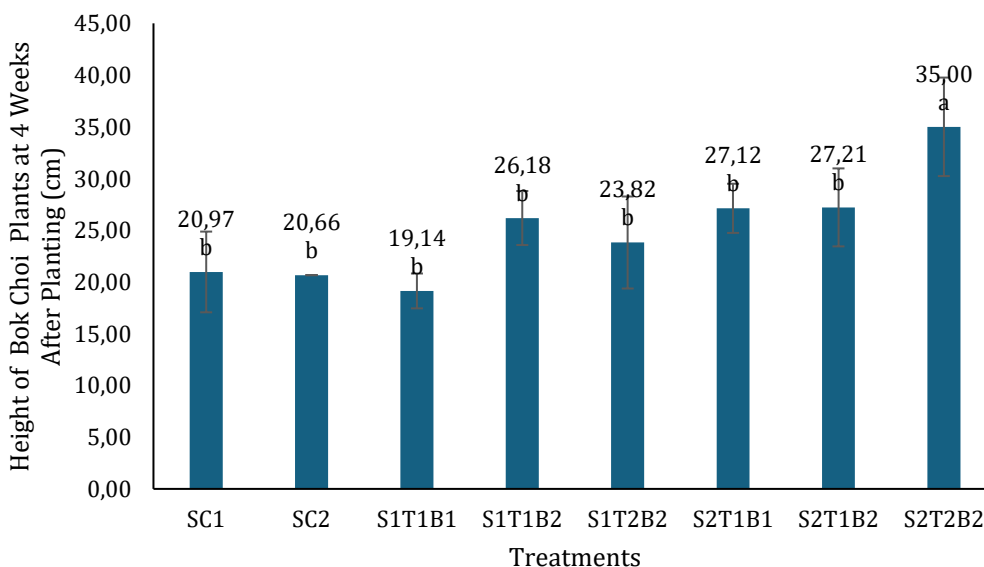


Figure1. Height of Bok Choi Plants at 4 Weeks After Planting (Processed data, 2025)

The S2F2B2 treatment exhibited the highest plant growth at 4 weeks after planting (WAP). This indicates that the combined application of biochar-coated humic acid and Tithonia compost fertilizer was significantly more effective than individual treatments or the absence of organic amendments. Biochar-coated humate (Bicomat) is a composite material consisting of biochar, humic acid, and adhesive polymer. The combined application of these components has been shown to enhance the average growth of water spinach (34–65 cm), spinach (35–46 cm), and mustard greens (21–28 cm) (Hamzah et al., 2022). These findings also suggest that soil from former C-excavation mining sites has the potential for rehabilitation through the appropriate application of fertilizers or soil amendments. This aligns with previous research by Hamzah et al. (2023), which reported that a Bicomat dosage of approximately 20 t/ha resulted in superior plant growth

compared to other dosages. These results further reinforce that the application of Bicomat at an optimal dosage is effective in improving the condition of degraded soils.

The availability of organic matter is very important to increase soil fertility and support plant growth (Widowati et al., 2025). The optimal combination of fertilizer and biochar is known to be able to improve soil structure, increase soil binding capacity to water and nutrients which are very necessary for bok choy plants, especially in marginal soil conditions such as ex-excavation soil C. Research by Bannepadang (2022), revealed that the provision of tithonia compost decomposition POC can increase the average plant height by 31% compared to the control and is in line with the findings in this study which highlight the importance of organic matter balance for maximum plant growth effectiveness.

Root length 4 WAP

Based on the observation, the root length of bok choy at 4 weeks after planting (WAP) exhibited variations across treatments, although statistical analysis indicated no significant differences ($p= 0.118$). In the control treatment, agricultural soil without amendments (CS1) had a root length of 11.90 cm, while in former C-excavation mining soil (CS2), the root length was shorter at 8.42 cm. The application of a combination of biochar-coated humate (Bicomat) and Tithonia compost resulted in an increase in root length in the former mining soil, with the highest value recorded in treatment S2F2B2 (15.36 cm). Similarly, in agricultural soil, the combination of Bicomat and Tithonia compost led to the longest root growth in treatment S1T1B1 (15.96 cm) (Figure 2).

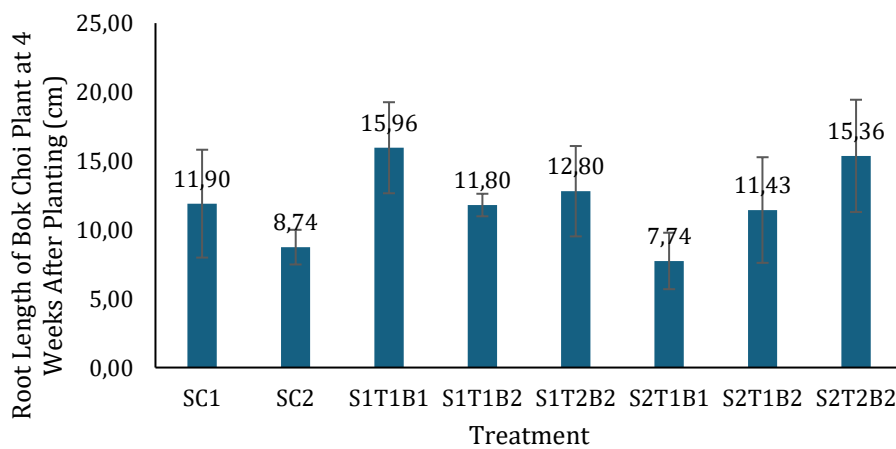


Figure2. Root Length of Bok Choi Plant at 4 Weeks After Planting (Processed data, 2025)

Although the results did not show a significance in statistical analysis, the increase in root length of the treatment on ex-mining soil C showed that the application of biochar and tithonia compost fertilizer helped in improving the degraded soil as seen in the S2T2B2 treatment. Biochar is known to improve soil physical and chemical properties, such as increasing cation exchange capacity (CEC), soil aeration, and air retention, and can support root growth better compared to untreated (Gao et al., 2023; An et al., 2023). However, in several studies, biochar can also adsorb certain nutrients, resulting in the release of nutrients more slowly. The combination of biochar with organic compost such as tithonia can create a synergistic effect, increased soil fertility and encourage plant growth (An et al., 2023).

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Another factor that can influence root growth is soil texture and structure. Ex-mining soil tends to have a denser structure and is poor in organic matter (Table 1), so even though there is an increase in root length after treatment, the roots can still be hampered due to limited pore space for the roots to penetrate. On agricultural land, with more fertile conditions and a looser structure, treatment with biochar and fertilizer may not have too big an effect because the soil conditions already support optimal root growth. This explained why in agricultural soil (S1) at increased doses of biochar and tithonia fertilizer (S1T2B2) tend to reduced root length. Ginting et al., (2018) emphasize the need to add organic material to post-excavation soil C, these findings highlight that this soil has low air absorption capacity and is poor in nutrients, so it requires intervention in the form of organic material.

Number of Leaves

The number of leaves in bok choy plants indicated that the application of a combination of Bicomat and Tithonia compost influenced leaf development at 4 weeks after transplanting (WAP) ($p: 0.000111$). The control treatment in agricultural soil (CS1) showed better results compared to the control treatment in former C-excavation mining soil (CS2), which consistently had fewer leaves throughout the 4-week observation period. Among the treatments, S1T1B2 recorded the highest leaf count at 4 WAP (17 leaves) (Figure 3).

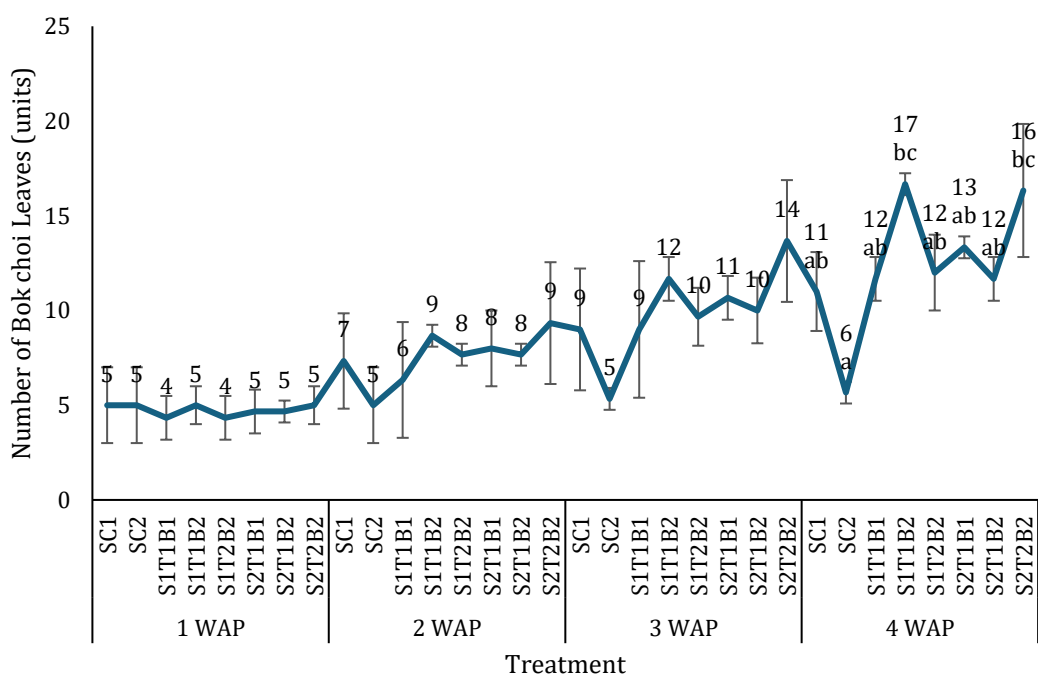


Figure 3. Number of Bok choy Leaves (Processed data, 2025)

The application of a higher dose of biochar, which is 20 t/ha (B2 treatment), showed a significant increase in the number of bok choy leaves in 4 WAP, especially treatments S1T2B2 and S2T2B2. The success of this treatment indicates that biochar and humic acid not only function as soil physical improvements but also contribute to increasing the availability of nutrients that are important for plant growth. Humic acid plays a crucial role in soil fertility, acting as a chelator that enhances the solubility and availability of essential nutrients for plants. This organic component improves nutrient retention capacity and promotes microbial activity, which further aids in the decomposition of organic matter and the release of nutrients into the soil solution (Zou et al.,

2023). Studies have shown that the co-application of biochar and humic acid improves overall soil health and contributes positively to crop yield (An et al., 2023; An et al., 2022).

The increase in the leaf number was statistically different at 4 WAP. This explains the combination of these two amendments provides a double benefit: the structural benefits of biochar combined with the nutrient-enhancing properties of humic acid as a long-term effect. Biochar contributes to increasing food security because of its ability to restore nutrients that have been reduced and improve soil quality, so that agricultural land or plantations can be used for a longer period (Wahyuni et al., 2023). The provision of fertilizer with a higher dose (300 g/polybag) also supports this result by providing the nutrients needed by plants.

Meanwhile, the difference in growth seen between agricultural land (SC1) and post-mining land (SC2) can be explained by the difference in nutrient content in the two types of soil. Agricultural land naturally contains more organic matter and nutrients that support plant growth, while post-mining land with lower organic matter content tends to be less fertile. Agricultural land usually contains a lot of organic matter and nutrients that support plant growth, while shallow soil tends to be dry, these conditions do not support optimal plant growth (Handayanto et al., 2017). Treatment with fertilizer and biochar made a significant contribution to improving the quality of post-mining soil, which was reflected in the increase in the number of leaves in the S2T2B2 and S2T1B2 treatments.

Fresh weight-Dry Weight

The research results indicate that the combination of Tithonia compost and Bicomat had a significant effect on the fresh weight ($p: 0.00863$) and dry weight ($p: 0.0446$) of bok choy grown in two different soil types. The control treatment on former C-excavation mining soil (CS1) recorded the lowest fresh and dry weight (20 g and 6.8 g, respectively), compared to all other treatments. In contrast, the S1T1B2 treatment (agricultural soil, 200 g compost, 20 t/ha Bicomat) achieved the highest fresh and dry weight (91.1 g and 15.3 g, respectively) among all treatments (Figure 4) followed by the S2T2B2 treatment on soil 2. This shows that high doses of Tithonia combined with maximum doses of bicomat can optimally increase plant vegetative growth. The high nutrient content of tithonia and the ability of bicomat to improve soil structure and nutrient retention are the main factors that support the increase in plant biomass. Research indicates that the incorporation of Tithonia leaves into soil can significantly improve soil fertility, thus leading to increased crop biomass (Liu et al., 2023; An et al., 2023).

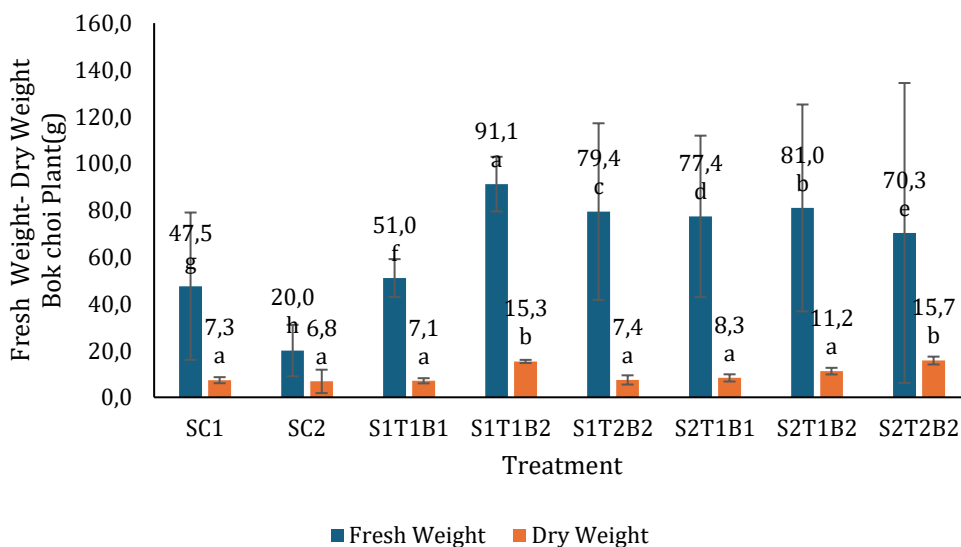


Figure4. Fresh Weight- Dry Weight Bok choy Plant (Processed data, 2025)

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In general, plants grown on soil 1 (agriculture) showed higher weight compared to soil 2 (ex-mining), both in the control and treatment. However, there was a significant difference between the control soil 2 (SC2) and the S2T2B2 treatment, indicating the effect of land recovery by the combination application of bicomat and tithonia. This treatment can compensate for the limited fertility of mining soil by increasing the availability of nutrients and the capacity of the soil to retain water and nutrients. This means that active organic materials such as bicomat not only act as ameliorant but also act as carriers and buffers of nutrients from organic fertilizers such as tithonia. Its porous structure of biochar helps retain nutrients and moisture, preventing leaching and promoting nutrient availability (Bao et al., 2024).

The combination of rapidly available organic input (Tithonia) and long-term buffer input (bicomat) produces a synergistic effect on bok choy growth. Tithonia provides N, P, and K in easily decomposed forms, thus supporting the early phase of plant growth, while bicomat increases nutrient utilization efficiency by improving soil physical and chemical quality. Tithonia's unique composition includes high levels of nitrogen, phosphorus, and potassium, which are vital for plant development. For example, studies confirm that the application of Tithonia improves the nutrient status of the soil, which in turn enhances the growth performance of various crops (Liu et al., 2023). Moreover, the release of nutrients from Tithonia contributes to better root development, leading to a more robust and vigorous biomass production. Its decomposed matter not only improves the soil structure but also increases microbial activity, further aiding nutrient cycling and availability for plants (An et al., 2023). Research by Gao et al. highlights the effectiveness of biochar in retaining nitrogen, which is critical for plant growth, while also demonstrating the positive effects of humic substances in enhancing nutrient uptake (Gao et al., 2023).

An increase in dry weight also shows that the nutrients absorbed not only increase the plant's water mass but are converted into structural biomass. This is important as an indicator that the plant's physiological processes are running well until the final stage of growth. Furthermore, the processes by which these nutrients are transformed into structural biomass involve complex interactions at the cellular level. For example, adequate nutrient supply, particularly nitrogen, promotes protein synthesis, which is crucial for cellular development in plants. As the nutrient levels in the plant tissues increase, the capacity for structural growth is subsequently enhanced, increasing both the plant's mass and height (Guan et al., 2018). The effective management of soil nutrients is therefore essential in agricultural practices aimed at optimizing plant growth and ensuring robust biomass production (Xin et al., 2019). This holistic understanding of nutrient dynamics exemplifies the vital role that nutrient absorption plays, not only in promoting aerial growth but also in establishing the structural integrity of the plant.

CONCLUSION

The addition of Bicomat and Tithonia Compost showed differences in plant height 4 MST, number of leaves 4 MST, fresh weight-dry weight of bok choy plants. The combination of Bicomat and Tithonia Compost S2T2B2 treatments was more optimal in increasing plant height 4 MST, number of leaves 4 MST, dry weight of mustard plants on post C-excavation mining land. The S1T1B2 treatment was optimal in increasing plant height 4 MST, number of leaves 4 MST, dry weight of bok choy plants on agricultural land. The T2B2 (300 g Tithonia Compost + Bicomat 20 t/ha) dose produced the best effect on bok choy plant growth on post-excavation soil, while the T1B2 (200 g Tithonia Compost + Bicomat 20 t/ha) treatment produced the best treatment on agricultural land.

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