



Reclamation of Post-Gold Mining Land Using Mycotrichocompost and Biochar: Effects on Corn (*Zea Mays* L.) Growth and Yield

Yummama Karmaita ^{a,*}, Dara Latifa ^b, Rita Wati ^c, Ari Wahyuni ^d, Risa Wentasari ^e, Amda Resdiar ^f, Nurholis ^g

^a Food Crop Production Technology Study Program, Politeknik Pertanian Negeri Payakumbuh, Lima Puluh Kota, Indonesia

^b Plantation Management Study Program, Politeknik Pertanian Negeri Payakumbuh, Lima Puluh Kota, Indonesia

^c Seed Technology Study Program, Politeknik Pertanian Negeri Payakumbuh, Lima Puluh Kota, Indonesia

^d Seed Technology Study Program, Politeknik Negeri Lampung, Bandar Lampung, Indonesia

^e Food Crop Production Technology Study Program, Politeknik Negeri Lampung, Bandar Lampung, Indonesia

^f Agroecotechnology Study Program, Universitas Teuku Umar, Aceh Barat, Indonesia

^g Agroecotechnology Study Program, Universitas Trunojoyo Madura, Bangkalan, Indonesia

Abstract. *Post-gold mining lands are severely degraded ecosystems requiring intensive restoration to recover their agricultural productivity and ecological functions. One promising approach to enhance soil biological, chemical, and physical properties is the application of biochar combined with mycotrichocompost. This study aims to evaluate the effects of biochar and mycotrichocompost on soil nutrient availability (N, P, K) and on the growth and yield of maize cultivated on post-gold mining soil. The study used a factorial randomized block design: level 1 giving Biochar (0 tons/ha, 4 tons/ha, 8 tons/ha, 12 tons/ha), and level 2 fertilizer application mycotrichocompost at different doses (0 tons/ha, 5 tons/ha, 10 tons/ha), resulting in 12 treatment combinations with 3 replication, resulting in total 36 experimental units. Data were analyzed using analysis of variance (ANOVA), followed by Tukey's Honest Significant Difference (HSD) test at $\alpha = 0.05$ using minitab 19. The addition of biochar and mycotrichocompost to former gold mining soil increased crop yields (9.93 tons/ha), plant growth (e.g., plant height: 152.3 cm and leaf length: 80.33 cm), physiological characteristics (e.g., chlorophyll a: 0.34 mg per gram of fresh leaf weight, chlorophyll b: 0.24 mg per gram of fresh leaf weight), and soil nutrient content (N: 0.14%, P: 271 ppm, and K: 1.87 ppm). In general, treatment A3B2 with a dose of 12 tons/ha of biochar plus 10 tons/ha of mycotrichocompost is the optimal combination.*

Keywords: Soil fertility; Agricultural sustainability; Environmental restoration.

Type of the Paper: Regular Article.



1. Introduction

Future ecological crises are no longer a distant possibility. Instead, they have become a modern reality that exceeds environmental tolerance and adaptive capacity. Ecological degradation from mining activities has become an urgent global concern, particularly in mineral-rich developing countries where environmental regulations are often inadequately enforced. Post-mining land degradation threatens both ecosystem services and agricultural productivity. Indonesia

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<https://doi.org/10.55043/jaast.v10i1.474>

Received June 25, 2025; Received in revised form February 11, 2026; Accepted February 11, 2026; Published February 28, 2026

* First corresponding author

Email: yummamakarmaita18@gmail.com

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is a country rich in natural resources, including agricultural and mining products. However, significant challenges in mine management persist, particularly regarding post-mining rehabilitation, resulting in unreclaimed excavation sites. Natural resources are a crucial source of funding for national development; thus, they must be utilized as much as possible for the benefit of the Indonesian people while ensuring environmental sustainability. Mining is a primary method of natural resources utilization; however, it has both positive and negative environmental impacts. Although economically beneficial, mining activities cause severe environmental degradation, including soil quality deterioration, habitat destruction, landscape alteration, and aesthetic changes. It is crucial to realize that the environment and the wealth and its resources are gifts from God that must be preserved. Sustainable management of natural resources requires balancing economic development with environmental conservation [1].

Sijunjung Regency is a large gold-producing area in West Sumatra. Gold mining in Sijunjung has been practiced for generations. Traditionally, gold mining in watersheds was conducted traditionally using wooden Dulang tools made of wood; however, with technological advancements, mining now employs excavators, resulting in deep and extensive excavations. Gold mining has also expanded from watersheds to productive lands, such as rice fields. Following mining operations, the land is abandoned without rehabilitation, causing land degradation and reduced agricultural land. Therefore, action is needed to minimize further environmental damage. These efforts can be pursued through ecosystem reclamation by providing soil improvement materials in the form of microbe-enriched organic matter and biochar to improve soil conditions. According to Nadalia and Pulunggono [2], reclamation is the process of reclaiming degraded or abandoned land to regain part of its productivity and biotic function. According to WHO [3], reclamation not only restores soil and vegetation quality but also considers potential impacts on human health and the environment. For example, managing heavy metal contamination and preventing water pollution are essential to protecting communities living around mining sites. Furthermore, in contaminated soils, biochar might reduce the bioavailability of heavy metals to plants. Biochar has been shown to effectively reduce heavy metal bioavailability in contaminated soils through adsorption and immobilization mechanisms [4]. In addition, biochar application affects corn water-use efficiency and water balance components in Vertisols [5].

One organic compost fertilizer that contains the antagonist fungus *Trichoderma* sp. and Mycorrhizae is known as mycotrichocompost. Mycotrichocompost has many advantages, including the presence of macro- and micronutrients, enhanced soil structure, facilitated root growth, enhanced water retention, increased activity of beneficial soil microbes, and pest control. For various species, including tomatoes, potatoes, and many other cereal and vegetable crops under field conditions, mycorrhizal inoculation has been shown to positively affect growth, nutrient

uptake, and yield [6]. In the "San Luis" poblano pepper variety, mycorrhizal and actinomycetes boosted plant growth and biomass [7]. Kirinyuh (*Chromolaena odorata* L.) is a suitable organic material for mycotrichocompost production, offering an inexpensive and readily available source of nutrients and organic materials. Although Kirinyuh commonly grows along roadsides, it is also found in dense shrubs on abandoned land and in areas left over after gold mines. However, it is not widely utilized as a source of organic matter. Kirinyuh contains 2.95% N, 3.02% K, and 0.35% P [8,9].

Recent studies have highlighted the potential of biochar remediating post-mining soils [10], and the efficacy of arbuscular mycorrhizal fungi in restoring heavy metal-contaminated soils [11]. However, the combined application of biochar and mycotrichocompost enriched with mycorrhiza and *Trichoderma* in gold mining soils, particularly to enhance N, P, K nutrients and maize productivity, remains insufficiently explored. While biochar and mycorrhizal inoculation have been studied separately for mine soil rehabilitation, their combined effects on nutrient dynamics and crop productivity in mercury-contaminated gold mining soils remain unclear. Furthermore, the synergistic mechanisms between biochar and mycorrhiza *Trichoderma* enriched compost have not been elucidated. This study addresses these gaps by investigating their interaction effects on soil fertility restoration and maize production in post-gold mining soils.

This study aims to determine the extent to which biochar and mycotrichocompost enhance soil N, P, and K availability, as well as maize growth and yield, in former gold mining soil.

2. Materials and Methods

2.1. The Research design

The study employed a factorial randomized complete block design with two factors: level 1 involved the application of biochar (A0 = 0 tons/ha, A1 = 4 tons/ha, A2 = 8 tons/ha, and A3 = 12 tons/ha) while level 2 applied mycotrichocompost fertilizer at varying concentrations (B0 = 0 tons/ha, B1 = 5 tons/ha, and B2 = 10 tons/ha). Factor A was biochar application rate (A0 = 0, A1 = 4, A2 = 8, and A3 = 12 tons ha⁻¹) and Factor B was mycotrichocompost application rate (B0 = 0, B1 = 5, and B2 = 10 tons ha⁻¹). Data were analyzed using analysis of variance, followed by the Honest Significant Difference (HSD) test at a 5% significance level.

2.2. Research Procedure

2.2.1. Mycotrichocompost preparation

Mycotrichocompost was prepared using kirinyuh plants, rice bran, *Trichoderma sp*, Mycorrhizae, and brown sugar. While the tools used are buckets, sieves, black plastic, sacks, and machetes. First, the kirinyuh was chopped into 2–5 cm pieces using a machete. Second, *Trichoderma sp.* and brown sugar were dissolved in one liter of water. The materials were then

arranged in layers consisting of kirinyuh, bran, and the *Trichoderma* solution until all materials were used, after which the pile was covered with black plastic. Third, the compost was turned once a week to maintain a stable temperature. If the compost was dry, water was added to maintain moisture content. Fourth, after one month of incubation, the compost matured, characterized by a soil-like texture, brownish-black color, crumbly structure, cool temperature, and absence of odor. Fifth, Arbuscular Mycorrhizal Fungi (AMF) were added to the mature compost and incubated for an additional week.

2.2.2. Soil sampling

Sampling was conducted using Simple Random Sampling (SRS) at an altitude of ± 150 meters above sea level. Soil samples were collected from a former gold mine of Nagari Palaluar, Koto VII District, Sijunjung Regency, West Sumatera.

2.2.3. Treatment

Soil Treatment involved placing 12 kg of soil into polyethylene bags (polybags) measuring 50 cm \times 40 cm. After the planting media were prepared, the designated treatments were applied, and the soil was incubated for a week.

2.2.4. Cultivation of Corn Crops

The corn variety used was Pioneer 32. Corn was planted in polybags filled with soil previously treated with biochar and mycotrichocompost; each polybag was planted with one corn seed. Stitching: Stitching was conducted if plants failed to grow or showed abnormal growth, one week after planting. Replanting: Non-germinated seeds or abnormal seedlings were replaced with healthy seedlings one week after planting to ensure uniform plant stands. Weeding: Weeding was conducted manually by removing weeds growing inside the polybags. Fertilization: Chemical fertilizers were applied at rates of 300 kilograms urea, 150 kg of SP-36, and 100 kg of KCl per hectare. Harvest: Harvesting was conducted at physiological maturity, indicated by a formation of a black layer of at least 50%.

2.3. Observation Variables

2.3.1. Soil nutrient analysis

Soil samples were collected from each polybag two weeks after treatment. Approximately 500 g of soil was collected from the root zone of each polybag, air-dried, ground, and sieved through a 2-mm mesh for chemical analysis. Soil chemical properties were analyzed, including total nitrogen (N) using the Kjeldahl approach, available phosphorus (P) using the Bray II method, and interchangeable potassium (K) extracted with ammonium acetate pH 7.

2.3.2. *Vegetative growth, physiological characters, and Generative Growth of Plants plant generative growth*

Plant height and leaf length were measured during vegetative growth observations. Generative growth observations included ear length, ear weight, 100 kernel weight, and crop yield per hectare. The physiological characteristics measured was chlorophyll content. Chlorophyll content was measured at eight weeks after planting by sampling maize leaves. Materials and tools used were corn plant leaves, 80% acetone solution, filter funnel, spectrophotometric, Buchner funnel, dropper, measuring cup, knife, mortar, and measuring flask. Procedure: (1) 50 mg of fresh leaves was chopped (sliced) and ground using a mortar, then extracted with acetone to a final volume of 10 mL. Extraction was conducted in the absence of light. (2) The extract was transferred into a centrifuge tube and centrifuged at a 650 x 15 minute period. (3) Absorbance was measured using a spectrophotometer at wavelengths of 65 nm and 663 nm. (4) Chlorophyll content was calculated using the specific absorption coefficient determined by McKinney:

$$Ca = (12.7 \times D663 - 2.69 \times D645) / \text{fresh weight of extracted leaf sample} \quad (1)$$

$$Cb = (22.9 \times D645 - 4.68 \times D663) / \text{fresh weight of extracted leaf sample} \quad (2)$$

Note:

Ca = Chlorophyll a (mg per mg leaf fresh weight)

Cb = Chlorophyll b (mg per mg leaf fresh weight)

D645 = Absorbance reading at 645 nm

D663 = Absorbance reading at 663 nm

3. Results and Discussion

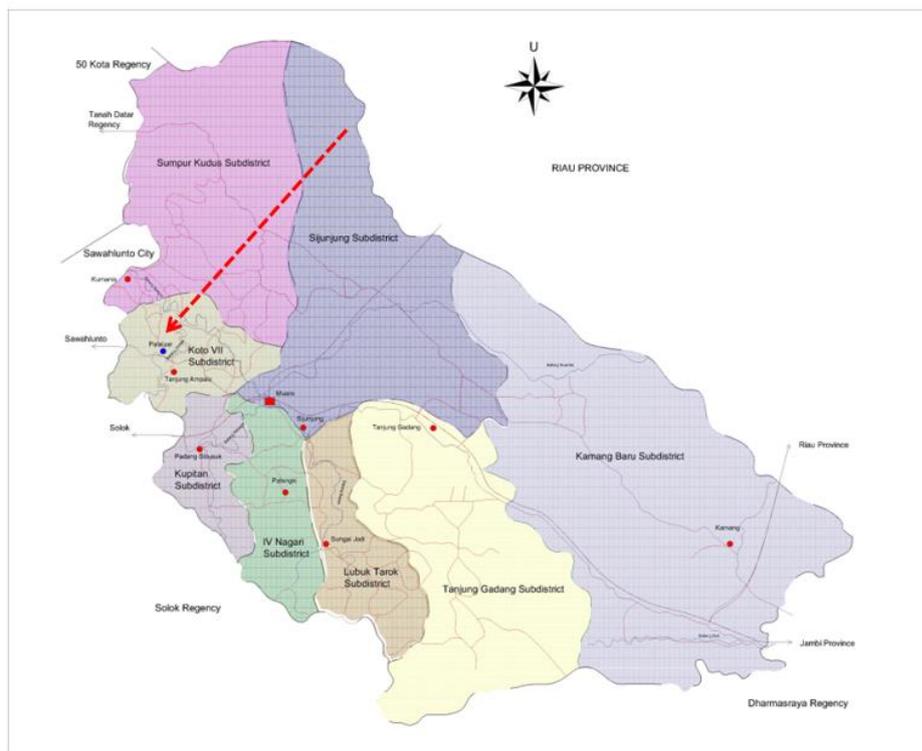
3.1. *Soil Sampling Location*

The study was conducted in post-gold mining sites in the nagari Palaluar, Koto VII district, regency of Sijunjung, West Sumatra, Indonesia (Fig. 1), located between 0°18'43" South Latitude – 1°41'46" South Latitude and 101°30'52" East Longitude – 100°37'40" East Longitude. Sijunjung Regency ranges in elevation from 120 and 130 m above sea level at the lowest areas to 550 and 930 m at the highest. The climate is classified as wet tropical, characterized by alternating rainy and dry seasons throughout the year. Temperatures range from a minimum 21°C to a maximum of 37°C. The average monthly rainfall, calculated from six monitoring sites, is 13.61 mm/day.

3.2. *N, P, and K content in soil*

ANOVA results indicated significant interaction effects between biochar and mycotrichocompost applications on soil P-available and K-exchangeable content ($P < 0.05$), but no significant effect on N-total (Table 1). Mycotrichocompost is an organic fertilizer containing mycorrhizal fungi and Trichoderma, which can enhance the soil P availability, as reported by Syofiani et al. [12]. The provision of mycorrhizae also increases P availability in former gold

mining soils. Elita et al. [13] reported that *Trichoderma spp.* efficiently mineralize organic matter, thereby increasing nutrient availability. Furthermore, Budianta et al. [14] stated that compost application increases N and P levels in post-tin mining tailings.



(<https://infopublik.sijunjung.go.id/sekilas-sijunjung/geografis/>)

Fig. 1. Map of the soil sampling location for research in the former gold mining site in Nagari Paluar, Koto VII Subdistrict, Sijunjung Regency, West Sumatera.

Biochar application has been reported to improve soil quality and fertility by increasing soil pH, enhancing moisture retention, stimulating beneficial microbes and fungi, improving cation exchange capacity, and preserving soil minerals [15,16]; however, these properties were not measured in the current study. Karim et al. [17] claimed that biochar can serve as a supplementary or replacement source of P fertilizer. In addition to directly supplying P, biochar can enhance P sorption and increase the availability of mineralized P. Biochar can supply P directly and may also reduce P fixation by soil minerals, thereby increasing P availability to plants. Because biochar is typically rich in potassium, it can boost soil K availability by adding salts that contain potassium. Several tropical studies have reported that biochar improves the total soil N status [18]. However, in this study, despite the addition of mycorrhiza, compost, and biochar, nitrogen in the former gold mining soil remained low, likely due to damaged soil conditions, limited microbial activity, heavy metal contamination, and environmental factors that hinder the decomposition and nitrogen fixation.

Table 1 shows that the N-total soil content was categorized as very low and low in both controls (without treatment) and the Biochar- and mycotrichocompost-treated soil. The addition of mycotrichocompost and biochar increased total soil N. The highest N-total value (0.14%) was

found in treatments A0B2, A1B2, A2B2, and A3B2. Available soil P was classified as very high in both untreated and treated. The application increased available P from 21.0 ppm to 271.0 ppm. This increase is attributed to several mechanisms. Biochar, due to its porous structure, can absorb phosphorus and increase soil pH, making phosphorus that is bound to metals such as aluminum and iron more available to plants. In addition, biochar enhances soil microorganism activity, which helps decompose organic matter and release phosphorus. Meanwhile, mycotrichocompost contains mycorrhiza that form symbiotic relationships with plant roots, improving the plant's ability to absorb phosphorus from the soil. Mycorrhiza expands the root absorption area and, together with compost microorganisms, facilitate the decomposition of organic matter and the release of bound phosphorus. Overall, both enhance soil phosphorus availability by improving soil structure, boosting microorganism activity, and facilitating the release of previously unavailable phosphorus.

Table 1. Effect of Biochar and mycotrichocompost on N-total, P- available, K-dd on ex-gold mining soil

Treatment	Nutrient Value					
	N-total (%)	Criteria	P-available: P ₂ O ₅ (ppm)	Criteria	K-dd (cmol/kg)	Criteria
A0B0	0.10	low	21.0	a	0.78	a
A0B1	0.13	low	158.0	g	1.18	b
A0B2	0.14	low	271.0	i	1.52	cd
A1B0	0.12	low	82.7	e	1.21	bc
A1B1	0.12	low	96.1	d	1.30	c
A1B2	0.14	low	191.0	f	1.56	d
A2B0	0.09	very low	25.0	a	0.84	ab
A2B1	0.11	low	66.9	c	0.97	b
A2B2	0.14	low	234.0	h	1.78	e
A3B0	0.11	low	38.9	b	0.96	b
A3B1	0.13	low	112.0	f	1.58	d
A3B2	0.14	low	242.0	h	1.87	e

The sources of soil criteria are correct: Soil and fertilizer instrument standard testing center (2023)

The numbers in the same column followed by the same letter are not significantly different according to the further test of Honest Significant Difference ($\alpha_{0.05}$)

The maximum available P content in the soil determined was observed in the A0B2 treatment (271.0 ppm), followed by A3B2 (242.0 ppm), A2B2 (234.0 ppm), and A1B2 (191.0 ppm). The available P content was classified as very high in both untreated and treated soil. The addition of biochar and mycotrichocompost increased the P-available content in the soil from 21.0 ppm to 271.0 ppm.

The soil exchangeable K (K-dd) content was classified as very low in both untreated and biochar- and mycotrichocompost-treated soils. However, the application of biochar and mycotrichocompost increased soil K-dd levels. The highest K-dd value was observed in treatment A3B2 (1.87 cmol kg⁻¹), while the lowest value (0.78 cmol kg⁻¹) was recorded in treatment A0B0 (untreated).

3.3. Plant height and leaf length

The application of mycotrichocompost and biochar on former gold-mining showed no interaction effect on plant height or leaf length. However, the single factor of mycotrichocompost showed a significant effect on plant height at the 5% significance level (Table 1). The main effect of mycotrichocompost on plant height was significant ($P < 0.05$; Table 2), with plant height increasing as the mycotrichocompost application rate increased.

Aromatic carbon (C) and trace amounts of other plant-growth-supporting nutrients, including S, Mg, Ca, P, K, and N, are found in biochars produced through pyrolysis [19]. According to Latawiec et al. [20], maize plants develop more quickly when biochar is applied at a rate of 50 tons ha⁻¹. Root fresh mass may rise when biochar and compost are combined [21]. Application of biochar inoculated with *Trichoderma aureoviride* on sandy soil effectively enhances chemical content, microorganisms, and soil enzymatic activity in the early growth of melon plants [22]. Sahiran and Sudantha [23] reported that bio compost fermented with *Trichoderma* spp. can function as (1) a nutrient source for plants and an energy sources for soil organisms; (2) a material that improve soil properties, increases sandy soil binding capacity, improves clay soil structure so that it is lighter, increases soil water holding capacity and improves drainage, (3) a promoter of plants grow and develop better, (4) a substrate that increases antagonistic microbial activity, and (5) a means of preventing soil-borne pathogens.

The results of the study by Diana and Oktabriana [24] demonstrated that the application of 43.2 g of *Trichoderma sp.* and 432 g of cow dung per planting hole increased the nutrient content and growth of citronella plants on former gold mine soil. *Trichoderma* species are frequently employed in agriculture to promote plant development and prevent crop diseases [25]. The growth of Typha grass (*Typha angustifolia*) is enhanced by the addition of mycorrhiza to gold mine tailings [26]. Mycorrhiza efficacy test on maize revealed a large difference in plant height at week ten in tailings media [27].

Table 2. Plant height and leaf length of maize after the application of biochar and mycotrichocompost treatment on ex-gold mine soil.

Plant Height (cm)				
Treatment	B0	B1	B2	Average
A0	78.00	135.00	135.00	116.00
A1	119.67	101.00	113.33	111.33
A2	130.00	137.67	128.33	132.00
A3	92.67	111.67	152.33	118.89
Average	105.08 A	121.33 B	132.25 C	
Leaf Length (cm)				
Treatment	B0	B1	B2	Average
A0	56.00	73.00	73.00	67.33
A1	69.33	67.00	66.67	67.67
A2	75.67	76.00	67.00	72.89
A3	62.33	69.00	80.33	70.56
Average	65.83	71.25	71.75	

According to [Table 2](#), adding biochar and mycotrichocompost to maize plants can increase their leaf length, which ranges from 56 to 80.33 cm, and their height, which ranges from 78.00 to 152.33 cm. For every hectare of the A3B2 treatment, 12 tons of biochar and 10 tons of mycotrichocompost are applied per hectare. This is presumably because the concurrent administration of biochar and organic fertilizers in the form of mycotrichocompost and inorganic fertilizer nutrients in the soil of ex-gold mines can be available and the use of inorganic fertilizers is more effective.

3.4. Chlorophyll a and b content

The application of biochar and mycotrichocompost on the ex-gold mining soil showed a significant interaction effect on chlorophyll a and b content in corn plants ([Table 3](#)). Significant interaction effects between biochar and mycotrichocompost were detected for chlorophyll a and chlorophyll b content ($P < 0.05$; [Table 3](#)). Both main effects (biochar and mycotrichocompost) were also significant. Agegnehu et al. [28] demonstrated that fertilizer additions to compost and biochar considerably improved leaf chlorophyll content compared to fertilizer application alone.

[Table 3](#) demonstrates that the application of biochar and mycotrichocompost to former gold mine soil changed chlorophyll a and b content in maize leaves. The highest chlorophyll content of the treatment combination was using a dosage of 10 tons of mycotrichocompost and 12 tons of biochar per hectare, A3B2 (which has 0.24 mg of chlorophyll b and 0.34 mg of chlorophyll a per milligram of fresh leaf weight).

Table 3. The content of chlorophyll a and b in corn plants after treatment with biochar and mycotrichocompost on ex-gold mine soil.

Content of chlorophyll a (mg per gram fresh weight of leaves)				
Treatment	B0	B1	B2	average
A0	0.11 a	0.24 bc	0.25 bc	0.20 A
A1	0.30 c	0.21 b	0.20 b	0.24 B
A2	0.21 b	0.29 c	0.23 bc	0.24 B
A3	0.19 b	0.30 c	0.34 c	0.28 C
average	0.20 A	0.26 B	0.25 B	
Content of chlorophyll b (mg per gram fresh weight of leaves)				
Treatment	B0	B1	B2	average
A0	0.04 a	0.07 a	0.07 a	0.06 A
A1	0.07 a	0.05 a	0.05 a	0.06 A
A2	0.05 a	0.03 a	0.05 a	0.05 A
A3	0.04 a	0.06 a	0.24 b	0.11 B
Average	0.05 A	0.05 A	0.10 B	

The numbers in the same column followed by the same letter are not significantly different according to the further test of Honest Significant Difference ($\alpha_{0.05}$)

3.5. Weight of 100 kernel and yield per hectare

The application of biochar and mycotrichocompost to ex-gold mine soil showed no interaction effect on 100 kernel weight and yield per hectare on maize. The average 100-kernel weight or grain yield per hectare is presented in [Table 4](#). ANOVA results indicated no significant

interaction between biochar and mycotrichocompost for 100-kernel weight or grain yield ($P > 0.05$). The main effects of both factors were significant for grain yield but not for 100-kernel weight (Table 4). Mycotrichocompos is an organic fertilizer containing compost with *Trichoderma* and mycorrhizal fungi, which are crucial for sustaining plant growth and development on post-gold mine land. Mycorrhizal fungi increase phosphorus availability in former mining soils, thereby enhancing maize productivity. Mycorrhizal fungi enhanced soil P availability (Table 1), which likely contributed to improved maize productivity through enhanced nutrient uptake. Tripaldi et al. [6] reported that although mycorrhizal treatment had insignificant effects, it tended to increase maize grain production. The application of biochar, ranging from 25% to 75%, can increase vegetative growth and yield in tomato plants [29].

The research results of Hermansah et al. [30] showed that improvement of paddy soil chemical properties in former gold mining areas after biochar application varied depending on the applied dose. These improvements were reflected in increased pH, organic C, available P, total N, and alkaline cation elements. The addition of rice husk biochar improved the chemical properties of abandoned gold mine soil by increasing soil pH and retaining nutrients supplied by inorganic fertilizers, thereby enhancing their availability to plants.

In two soil types differing in texture and mineralogy (sandy clay loam Oxic-Paleustalf and sandy loam Oxic-Paleustult), the combined application of rice husk biochar and nitrogen fertilizer improved the growth, yield components, soil nutrient availability, and N retention of rain-fed rice [31].

Table 4. The weight of 100 kernel and yield of kernel per hectare of maize after treatment with biochar and mikotrichocompost on ex-gold mine soil

Weight 100 kernel (grams)				
Treatment	B0	B1	B2	Average
A0	24.33	26.89	31.53	27.58
A1	28.88	33.80	28.94	30.54
A2	31.22	31.88	33.01	32.04
A3	31.97	31.52	33.51	32.33
<u>Average</u>	29.10	31.02	31.75	
The yield per hectare (tonnes)				
Treatment	B0	B1	B2	Average
A0	3.93	6.31	7.27	5.84
A1	4.58	6.82	9.93	7.11
A2	6.78	7.24	9.05	7.69
A3	7.99	8.03	9.58	8.54
<u>Average</u>	5.82	7.10	8.96	

Table 4 shows that, overall, the 100-kernel weight and grain yield per hectare of corn is not significantly different after the application of biochar and mycotrichocompost to ex-gold mining soil. The highest 100-kernel weight was found in the treatment A3B2 (33.52 grams), whereas the lowest was in treatment A0B0 (24.33 grams). The highest seed yield per hectare was found in treatment A1B2 (9.93 tons ha⁻¹), while lowest value was found in treatment A0B0 (3.93 tons ha⁻¹).

1). These results indicate that the use of trichocompost and biochar can increase grain yield per hectare and the weight. Higher doses of biochar and mycotrichocompost were associated with increased yield.

4. Conclusions

On former gold mine soil, the use of biochar and mycotrichocompost improved plant growth, physiological traits, crop yields, and soil nutrient content (N, P, and K). The combined application of biochar and mycotrichocompost significantly improved maize growth and yield on post-gold mining soil. The greatest improvements were observed in soil P availability (increasing from 21 to 271 ppm), chlorophyll content (up to 0.34 mg g⁻¹ FW for chlorophyll a), and grain yield (increasing from 3.93 to 9.93 t ha⁻¹). Overall, the most effective treatment regimen consisted of 12 t ha⁻¹ of biochar combined with 10 t ha⁻¹ of mycotrichocompost.

Abbreviations

Not applicable

Data Availability Statement

The data includes documentation of the research implementation, which is publicly available via the following link: https://drive.google.com/drive/folders/1WZ1g9Yiff8Nk0tMjY3mDT_yqNLU3yDxL?usp=sharing. We are also happy to provide reasonable assistance regarding our original images and data if the corresponding author is contacted.

CRedit Authorship Contribution Statement

Yummama Karmaita: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing. **Dara Latifa:** Data curation, Investigation, Methodology, Project administration and editing. **Rita Wati:** Data curation, Investigation, Methodology. **Ari Wahyuni:** Data curation, Investigation, Methodology. **Risa Wentasari:** Data curation, Investigation, Methodology. **Amda Resdiar:** Data curation, Methodology. **Nurholis:** Data curation, Methodology

Declaration of Competing Interest

The authors of this manuscript declare no conflict of interest or competing interest.

Declaration of Use of AI in the Writing Process

Nothing to disclose.

Acknowledgement

The Vocational Education Directorate General of the Ministry of Education, Culture, Research, and Technology provided funding for this study, for which the authors are grateful.

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