Vol. 14, No. 2, pp. xxx-xxx, Mei 2026 DOI: https://doi.org/10.23960/jat.v14i1.10948

Jurnal Agrotek Tropika

P-ISSN: 2337-4993
E-ISSN: 2620-3138

Journal homepage: https://jurnal.fp.unila.ac.id/index.php/JA

BIOCHAR AND ECO-ENZYME EFFECTS ON GROWTH, YIELD, AND TUBER QUALITY OF SWEET POTATO (Ipomoea batatas L.)

PENGARUH BIOCHAR DAN EKOENZIM TERHADAP PERTUMBUHAN, HASIL, DAN KUALITAS UMBI UBI JALAR (*Ipomoea batatas* L.)

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ARTICLE HISTORY:

Received: 10 June 2025
Peer Review: 29 July 2025
Accepted: 05 May 2026

KATA KUNCI:

Organic waste, rice husk, soil amendment, sweet potato, yield

ABSTRACT

As one of the important crops in Indonesia, the production of sweet potato remains below optimal levels across many fields, which can be attributed to insufficient soil fertility. Soil properties can be improved through biochar and eco-enzyme derived from organic waste, supporting crop growth and yield. The study aimed to evaluate the effects of rice husk biochar and eco-enzyme on the growth and yield components of sweet potato. The experiment was conducted from December 2023 to March 2024 at the Experimental Garden in the Faculty of Agriculture, Universitas Malikussaleh, using a randomized block design with 2 factors: biochar (0, 5, and 10 tons ha-1) and eco-enzyme (0, 22.5, and 30 ml) with 3 replications. The parameters measured included tuber length, tuber number and diameter, primary branch number, chlorophyll content, tuber fresh weight (per plant and per tuber), and organoleptic attributes (e.g., taste, color, texture). Biochar application at 5-10 tons ha-1 significantly increased tuber number and fresh weight per tuber compared with the control. Eco-enzyme at 22.5-30 ml mainly improved primary branch number and increased tuber fresh weight and organoleptic scores. Many parameters were not significantly affected, suggesting that under the relatively low amendment rates and single-season application used, biochar and eco-enzyme provide only moderate improvements in sweet potato performance.

ABSTRAK

Sebagai salah satu komoditas penting di Indonesia, produksi ubi jalar masih berada di bawah tingkat optimal pada berbagai lahan, yang dapat disebabkan oleh rendahnya kesuburan tanah. Sifat tanah dapat diperbaiki melalui biochar dan ekoenzim yang berasal dari limbah organik, sehingga mendukung pertumbuhan dan hasil tanaman. Penelitian ini bertujuan untuk mengevaluasi pengaruh biochar sekam padi dan ekoenzim terhadap pertumbuhan dan komponen hasil tanaman ubi jalar. Percobaan dilaksanakan dari Desember 2023 hingga Maret 2024 di Kebun Percobaan Fakultas Pertanian Universitas Malikussaleh, dengan menggunakan rancangan acak kelompok dengan dua faktor, yaitu biochar (0, 5 dan 10 ton ha-1) dan ekoenzim (0, 22.5 dan 30 ml) dengan tiga ulangan. Parameter yang diamati meliputi panjang umbi, jumlah dan diameter umbi, jumlah cabang primer, kandungan klorofil, bobot segar umbi (per tanaman dan per umbi), serta sifat organoleptik (rasa, warna, tekstur). Aplikasi biochar pada dosis 5–10 ton ha^{-1} secara signifikan meningkatkan jumlah umbi dan bobot segar per umbi dibandingkan kontrol. Ekoenzim pada dosis 22,5–30 ml terutama meningkatkan jumlah cabang primer serta bobot segar umbi dan skor organoleptik. Banyak parameter yang tidak terpengaruh secara nyata, yang mengindikasikan bahwa pada dosis amelioran yang relatif rendah dan aplikasi satu musim tanam, biochar dan ekoenzim hanya memberikan perbaikan moderat terhadap performa tanaman ubi jalar.

KEYWORDS:

Hasil, pembenah tanah, sampah organik, sekam padi, ubi jalar

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is a tuberous crop originating from Latin America and is cultivated in many regions, including Indonesia (Zulkadifta *et al*. 2019). This crop serves as both food and feed, with the tubers consumed as a staple and the leaves used as fodder, contributing significantly to the national economy (Yoandari *et al*. 2017; Dari *et al*. 2017). Per 100 g of yellow-fleshed sweet potato provides 27.9 g of carbohydrate, 27.68 mg of beta-carotene, 30 mg of calcium, 1.8 g of protein, 49 mg of phosphor, 0.7 mg of zinc, and 68.5 g of water (Sari *et al*. 2023). In addition, it contains antioxidants such as vitamins C and E, carotenoids, and anthocyanins, which may determine the organoleptic quality including taste, color, and texture of cooked tubers and are influenced by soil fertility and crop management (El Sheika & Ray 2017). In Aceh Utara (North Aceh), sweet potato is cultivated approximately on about 60 ha, with 50 ha harvested, productivity 61.50 quintal ha-1 and total production of 307.50 ton ha-1 (BPS Aceh Utara, 2016). Per capita sweet potato consumption in Aceh increased from 0.007 kg in 2021 to 0.015 kg in 2022, and 0.045 kg capita-1 week-1 in 2023 (BPS, 2021). Improving yield, therefore, requires not only appropriate fertilizer application but also improved management to sustain.

Biochar has been known as a soil conditioner that can improve soil fertility and crop performance (Zonayet *et al*. 2024). The application of rice husk biochar together with organic fertilizers has been reported to improve soil physical, chemical, and biological properties, leading to increasing crop yield (Oladele *et al*. 2019; Phuong *et al*. 2020; Rosnina *et al*. 2021; Candra *et al*. 2022). Positive effects of biochar on growth and yield have been shown in tomato and yard long bean (Adebajo *et al*. 2020; Rahaman *et al*. 2023). These responses are attributed to the porous structure and high cation exchange capacity of biochar, which enhance soil structure, water retention, and nutrient holding capacity, and thereby reduce nutrient leaching and improve nutrient availability to plants (Karimi *et al*. 2020; Rubin *et al*.2020).

Eco-enzyme has been applied to improve soil fertility and stimulate plant hormones, facilitating plant growth and crop quality (Benny *et al*. 2023; Haryuni *et al*. 2024). The enzyme is a liquid produced by fermenting fruit and vegetable waste with sugar and water, which can be used as an organic fertilizer or biostimulant (Defiani & Astarini 2023). The process converts organic waste into a value-added product and reduces methane emissions from unmanaged waste (Benny *et al*. 2023; Siregar *et al*. 2024). According to Rosnina *et al*. (2023), eco-enzyme application at 22.5 ml combined with mycorrhiza significantly increased the vegetative growth of Sacha inchi. Furthermore, Defiani and Astarini (2023) found that eco-enzyme also increased seed germination rates and improved early rice growth compared with the controls.

In this study, the aimed was to assess the effects of rice husk biochar and eco-enzyme application on sweet potato growth and yield. This is to response to the increasing demand for sweet potato in North Aceh and the need for sustainable soil management.

2. MATERIALS AND METHODS

2.1 Study Site and Experimental Period

This study was conducted at the Experimental Garden of the Faculty of Agriculture and the Agroecotechnology Laboratory, Universitas Malikussaleh, Reuleut, Muara Batu, North Aceh, Indonesia, from December 2023 to March 2024. The site is located in a lowland area with dryland conditions, which is representative for local sweet potato cultivation.

2.2. Plant Material, Soil Preparation and Cultural Practices

We used sweet potato Var. Sari (Sari Wortel) obtained from Saree, Aceh Besar Regency. The field was manually cleared and weeds were removed, after which the soil was loosened to facilitate root penetration and nutrient uptake. Raised beds of 200 cm length, 110 cm width and 30 cm height were prepared, with 50 cm spacing between beds. Cattle manure was applied as a basal organic fertilizer at 3.6 kg bed^{-1}, and the soil was left for about two weeks to allow amendment incorporation before planting. Two-month-old, healthy, pest- and disease-free slips were selected, trimmed to 20–25 cm length, and planted with approximately two-thirds of each slip inserted into the soil at 15 cm depth and 50 × 30 cm plant spacing.

Watering was carried out daily in the morning or evening during the first month after planting, followed by once-weekly irrigation and additional watering 2–3 weeks before harvest, when tuber formation was evident. Weeds were removed manually throughout the cropping period. Ridging (hilling) was performed at 1 and 2 months after planting to cover developing roots, improve aeration, and protect tubers. Plants were harvested approximately 4 months after planting, when the foliage had turned yellow.

2.3 Eco-enzyme Preparation and Application

Eco-enzyme was prepared by fermenting mixed fruit peels (e.g., banana, orange, mango, pineapple and cucumber), and vegetables waste with water (60%) and brown sugar (10%). The waste materials were mixed and placed in a large plastic container to minimize the risk of overpressure during fermentation and to avoid breakage. The containers were kept in a well-ventilated room, protected from direct sunlight, and left to fermented for 3 months. During fermentation, lids were opened in the first week to release accumulated gas, and the mixture was stirred on days 7, 30 and 90 to homogenize the contents. A mature eco-enzyme was characterized by a pungent acidic odour, pH below 4, and a brown, turbid appearance.

Eco-enzyme treatments consisted of three concentrations: 0 ml plot^{-1} (control), 22.5 ml plot^{-1}, and 30 ml plot^{-1}. Before planting, eco-enzyme was applied once at 10 days before planting by diluting the specified volume in water and distributing the solution evenly onto each plot as a soil drench. After planting, eco-enzyme was reapplied at 30 days after planting and then at 10-day intervals, resulting in a total of five applications during the experiment. Each application used the same concentration per plot according to the assigned treatment.

2.4 Biochar Preparation and Application

Rice husk biochar was produced using an open-drum kiln. A cylindrical metallic inner chamber with a perforated base and intact bottom was placed in the center of a metal drum, and rice husk was packed around the cylinder. Combustion was initiated at the base and allowed to proceed slowly under limited oxygen conditions, so that the rice husk underwent incomplete combustion rather than complete burning to ash. When most of the husk had turned black and lightweight, indicating carbonization, the drum was closed and the material allowed to cool to room temperature before handling to prevent further combustion. The resulting blackened rice husk (biochar) was then used as a soil amendment.

Biochar was applied at three rates: 0 kg plot-1 (control), 1.1 kg plot-1 (equivalent to 5 ton ha-1), and 2.2 kg plot-1 (equivalent to 10 ton ha-1). The biochar was placed uniformly onto the soil surface and incorporated into the topsoil 14 days before planting. In addition to the pre-planting application, a light reapplication of biochar was performed by spreading the material on the soil surface according to the assigned dose during the early growth stage, to maintain the amendment in the root zone.

2.5 Experimental Design and Statistical Analysis

The experiment was laid out as a randomized block design with a two-factor factorial arrangement. Three levels of rice husk biochar and three concentrations of eco-enzyme were combined to form nine treatment combinations, which were randomly allocated within each of three blocks, resulting in 27 plots with four central plants per plot used as observation units (108 plants in total). The specific rates and application procedures for biochar and eco-enzyme are described in the corresponding subsections of the Materials and Methods.

The observed variables comprised tuber length, primary branch number, chlorophyll content, tuber number, tuber diameter, tuber fresh weight, and organoleptic attributes (taste, colour, and texture). Tuber length was measured at 20, 30, 40, 50, and 60 days after planting (DAP) using a tape from the stem base to the distal end of the storage organ, while primary branches were counted on each plant at the same intervals. Chlorophyll content was assessed on fully expanded leaves at 20–60 DAP with a portable chlorophyll meter, expressed as chlorophyll content index (CCI). At harvest, tuber number per plant was recorded, tuber diameter was measured at the widest point using a vernier caliper, and tuber fresh weight was obtained both per plant (sum of all tubers) and per tuber (mean individual weight).

At harvest, tuber number per plant was recorded, tuber diameter was measured at the widest point using a vernier caliper, and tuber fresh weight was obtained both per plant (sum of all tubers) and per tuber (mean individual weight). Organoleptic quality was evaluated on boiled tubers using a simple hedonic test. A panel of 20 respondents scored taste, colour, and texture of coded samples on a three-point scale (1 = less preferred, 2 = moderately preferred, 3 = highly preferred). Tubers from each treatment were boiled in plain water until fully cooked, cut into uniform slices, and served warm in random order; panelists were not informed about the treatments to minimize bias. Mean scores for each attribute were calculated for each plot.

For each variable, plot means were subjected to factorial randomized complete block ANOVA followed by Duncan's multiple range test at the 5% significance level. All data were analyze using SPPS software.

3. RESULTS AND DISCUSSIONS

3.1 Tuber Growth Dynamic

Table 1 shows biochar and eco-enzyme effect on tuber length of sweet potato. At 60 DAP, biochar applied at 5 t ha^{-1} increased tuber length by approximately 7% compared with the control (89.41 vs. 83.41 cm), whereas increasing the rate to 10 t ha^{-1} resulted in only a ~6% increase (88.41 cm), indicating no additional benefit from the higher application rate. Eco-enzyme exhibited a clearer response pattern, with tuber length at 60 DAP increasing from 89.81 cm in the control (0 ml) to 91.46 cm at 22.5 ml (+2%) and 94.13 cm at 30 ml (+5%), suggesting a dose-dependent, though statistically non-significant, enhancement in tuber elongation. Regardless of statistical significance, the consistent increases observed with both biochar and eco-enzyme indicate a positive but modest agronomic effect under the present experimental conditions.

The modest responses at 5–10 tons ha^{-1} are consistent with Andika *et al.* (2019), who reported that 5 and 10 tons ha^{-1} biochar did not significantly affect sweet potato vine length. However, Walter & Rao (2015) observed that 5 tons ha^{-1} biochar significantly increased the performance of sweet potato, indicating that positive responses can occur at similar rates under other soil and management conditions. Such discrepancies likely reflect differences in biochar properties, as Figueredo *et al*. (2017) showed that sewage sludge biochar produced at 350 °C contained a greater nitrogen (3.17%) than biochar from sugarcane (1.4%) or eucalyptus waste (0.4%), which would be expected to induce stronger growth responses. Several other studies further demonstrate that higher biochar dose can significantly improve sweet potato yield; Adekiya *et al*. (2022) reported that 20 tons ha^{-1} biochar produced greater growth and yield than 10 tons ha^{-1}. Nevertheless, Jay *et al* (2015) emphasized that short-term biochar application may not translate into significant yield gains, and are often more pronounced over longer cropping cycles.

3.2 Primary Branches Development

Biochar and eco-enzyme showed a clear increasing trend in the number of branches although significant differences were limited to early growth (Table 2). At 20 DAP, 5 tons ha^{-1} biochar increased branch number by about 37% compared with the control (1.17 vs 0.85 branches plant^{-1}), whereas 10 tons ha^{-1} raised it by about 13% (0.96 branches plant^{-1}), but these differences were no longer significant at later observations. For eco-enzyme, plants receiving 22.5 and 30 mL plot^{-1} produced slightly more branches than the control at most dates, with the largest relative increase at 60 DAP (3.86 vs 3.11 branches plant^{-1}, approximately +24% for 22.5 ml), yet these effects were also not statistically significant beyond 20 DAP.

These non-significant but positive trends are consistent with the view that biochar persists in the soil and gradually improves nutrient availability and root environment rather than inducing strong, immediate changes in shoot architecture. Agbede & Oyewumi, 2022 higlighted that biochar can enhance soil physical and chemical properties and thereby sustain plant growth, even when short-term yield responses are limited. The modest branching response at 5–10 tons ha^{-1} may reflect the relatively low dose and the already improved soil condition due to cattle manure, which reduces the marginal benefit of additional carbon inputs. Rivera *et al*. (2022) also reported that, although biochar has desirable properties, plants growth response can remain small, but its use still contributes to reducing dependence on synthetic fertilizers.

3.3 Leaf Chlorophyll Content

Table 3 shows that chlorophyll content index (CCI) did not differ significantly among biochar or eco-enzyme treatments at any sampling date, and no interaction between the two factors was detected. Nevertheless, CCI increased over time for all treatments, with numerically higher values in plants receiving 5–10 tons ha^{-1} biochar and 22.5–30 ml eco-enzyme, particularly at 50–60 DAP, suggesting a slight improvement in leaf chlorophyll status that remained below the threshold of statistical significance.

Table 1. Effect of Biochar and Eco-enzyme Applications on Sweet Potato Tuber Length.

Treatment	Tuber length (cm)				
	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP
---------- Biochar (ton ha^{-1}) ----------					
0	13.20 b	24.25	40.08	61.94	83.41
5	15.58 a	25.47	48.00	69.80	89.94
10	15.48 a	25.11	44.55	66.15	88.41
---------- Eco-enzyme (ml) ----------					
0	14.67 a	24.83	43.66	68.66	83.69
22.5	14.67 a	24.91	44.70	49.88	84.22
30	14.92 a	24.83	44.22	69.36	94.13

Note: Means in the same column followed by different letters are significantly different by Duncan's Test at 5% probability level.

Table 2. Effect of Biochar and Eco-enzyme Applications on Sweet Potato Tuber Length.

Treatment	Number of primary branches				
	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP
---------------------------------- Biochar (ton ha^{-1}) ----------------------------------					
0	0.85 b	1.47	1.94	2.22	3.22
5	1.17 a	1.88	2.25	2.72	3.66
10	0.96 b	1.50	2.00	2.55	3.72
---------------------------------- Eco-enzyme (ml) ----------------------------------					
0	0.93	1.47	1.97	2.11 b	3.11 b
22.5	1.02	1.77	2.08	2.86 a	3.86 a
30	1.00	1.61	2.13	2.25 ab	3.63 a

Note: Means in the same column followed by different letters are significantly different by Duncan's Test at 5% probability level.

Table 3. Effect of Biochar and Eco-enzyme Applications on Sweet Potato Chlorophyll Content Index (CCI).

Treatment	Chloropyhll content index (CCI)				
	20 DAP	30 DAP	40 DAP	50 DAP	60 DAP
---------------------------------- Biochar (ton ha^{-1}) ----------------------------------					
0	13.14	14.36	14.70	15.76	17.10
5	13.41	14.53	15.58	16.46	17.55
10	13.41	14.71	14.73	16.11	17.42
---------------------------------- Eco-enzyme (ml) ----------------------------------					
0	12.80	14.29	14.42	15.32	17.15
22.5	12.44	14.38	14.91	16.32	17.55
30	13.72	14.93	16.67	16.27	17.36

Note: Means in the same column followed by different letters are significantly different by Duncan's Test at 5% probability level.

Chlorophyll content is a key indicator of plant nutritional status and photosynthetic capacity and is frequently used to infer nitrogen supply and assimilate production potential (Zhao & Zhang 2021). Recent work has shown that biochar can enhance chlorophyll and carotenoid contents, especially under stress conditions, although responses depend strongly on biochar type, rate, and soil environment. The absence of a clear CCI response in the present study is therefore consistent with reports that biochar applied alone at moderate rates or to relatively fertile soils may have limited short-term effects on chlorophyll, particularly when crops are not nutrient-stressed. Similarly, eco-enzyme has been reported to increase chlorophyll content in leafy vegetables, but the magnitude of response depends on concentration and growing conditions, so the modest, non-significant increases observed here likely reflect both the conservative dose range and the short experimental duration (Yang *et al.* 2024).

3.4 Tuber Number and Diameter

Table 4 shows that biochar significantly increased tuber number but did not affect tuber diameter, whereas eco-enzyme had no significant effect on either trait. Plants without biochar produced the fewest tubers (2.25 tubers plant^{-1}), while 5- and 10-tons ha^{-1} increased tuber number by about 26% and 22% (2.83 and 2.75 tubers plant $^{-1}$), with similar diameters (45.26–48.04 mm). Eco-enzyme treatments resulted in only small, non-significant differences in tuber number (2.55–2.69 tubers plant−1) and diameter (46.12–47.92 mm).

These results suggest that biochar mainly promoted tuber initiation rather than enlargement, consistent with reports that biochar can increase the number of storage organs without markedly changing their size when applied at moderate rates. Edussuriya *et al.* (2023) similarly observed that 5–20 tons ha^{-1} biochar increased sweet potato tuber number, whereas Andika *et al.* (2019) found no significant effect of paddy straw biochar on tuber number, indicating that responses depend strongly on biochar type and site conditions.

3.5 Tuber Fresh Weight

Table 5 shows that biochar markedly increased tuber fresh weight, while effects on tuber fresh weight per plant and eco-enzyme responses were more variable. Application of 5- and 10-tons ha^{-1} biochar increased tuber fresh weight by about 23–24% compared with the control (165.49–166.49 g vs 134.50 g), whereas fresh weight per plant rose numerically from 1639 g to 1930–1806 g but without statistical significance. For eco-enzyme, 22.5 ml plot^{-1} produced the highest tuber fresh weight (179.87 g, +16% over 0 ml), whereas 30 ml reduced this parameter to 130.53 g despite similar or slightly higher fresh weight per plant (1845 g) compared with 0 and 22.5 ml (1720–1789 g).

These results are in line with previous reports that moderate biochar doses enhance tuber or root weight through improved soil structure and nutrient availability, even when whole-plant yield gains are modest. Indawan *et al*. (2019), for example, observed significant increase in sweet potato and potato tuber weight at around 5 tons ha-1 biochar, whereas other studies noted limited yield effects at lower rates or under relatively fertile conditions, underscoring the context dependence of biochar responses. The observed eco-enzyme pattern, characterized by a positive effect at 22.5 mL followed by a decline at 30 mL, is consistent with reports that eco-enzyme functions as a biostimulant with an optimal concentration range. Haryuni *et al*. (2024) and Jaya *et al*. (2021) similarly documented increases in root or bulb fresh weight at moderate eco-enzyme application rates, with little to no additional benefit at higher doses.

Table 4. Effect of Biochar and Eco-enzyme Applications on Sweet Potato Tuber Number and Diameter.

Treatment	Tuber number	Tuber diameter (mm)
---------- Biochar (ton ha^{-1}) ----------		
0	2.25 b	45.26
5	2.83 a	48.30
10	2.75 a	48.04
---------- Eco-enzyme (ml) ----------		
0	2.55	46.12
22.5	2.69	47.56
30	2.58	47.92

Note: Means in the same column followed by different letters are significantly different by Duncan's Test at 5% probability level.

Table 5. Effect of Biochar and Eco-enzyme Applications on Sweet Potato Tuber Fresh Weight.

Treatment	Tuber fresh weight (g)	Yield per plant (g)
---------- Biochar (ton ha^{-1}) ----------		
0	134.50 b	1639
5	165.49 a	1930
10	166.49 a	1806
---------- Eco-enzyme (ml) ----------		
0	156.08 b	1720
22.5	179.87 a	1789
30	130.53 c	1845

Note: Means in the same column followed by different letters are significantly different by Duncan's Test at 5% probability level.

Figure 6. Effects of biochar and eco-enzyme application rates on sensory attributes (taste, colour, and texture) of boiled sweet potato.

Treatment	Taste	Colour	Texture
----------------------------------Biochar (ton ha^{-1}) ----------------------------------			
0	1.40 b	1.46 c	1.50
5	1.42 ab	1.52 b	1.50
10	1.44 a	1.57 a	1.52
---------------------------------- Eco-enzyme (ml) ----------------------------------			
0	1.33 c	1.46 c	1.43 c
22.5	1.44 b	1.59 a	1.57 a
30	1.49 a	1.51 b	1.53

Note: Means in the same column followed by different letters are significantly different by Duncan's Test at 5% probability level.

3.6. Organoleptic

Table 6 shows that both biochar and eco-enzyme influenced the sensory attributes of boiled sweet potato, particularly taste and colour. For biochar, increasing the application rate from 0 to 10 t ha^{-1} improved taste scores from 1.40 to 1.44 (+2.9%) and colour scores from 1.46 to 1.57 (+7.5%), while texture changed only slightly from 1.50 to 1.52 (+1.3%). The 10 t ha^{-1} rate produced the highest or equal-highest values across all three traits. For eco-enzyme, taste scores increased from 1.33 (0 ml) to 1.49 (30 ml; +12.0%), colour scores from 1.46 to 1.59 (22.5 ml; +8.9%), and texture scores from 1.43 to 1.57 (22.5 ml; +9.8%). These results indicate that applying 22.5–30 mL eco-enzyme per plot enhanced perceived taste, colour, and mouthfeel compared with the untreated control.

The observed organoleptic responses align with the role of biochar in enhancing soil fertility and nutrient uptake, thereby promoting carbohydrate and pigment accumulation in storage roots. Consistent with previous reports (Ali *et al*. 2020; Adekiya *et al*. 2022), the higher taste and colour scores at 10 t ha^{-1} indicate that moderate biochar application can improve consumer-relevant quality traits of sweet potato. Similarly, improved sensory scores at 22.5–30 mL eco-enzyme reflect its biostimulant effects on nutrient cycling and root activity, which may increase soluble sugars and flavour compounds. As reported for other crops (Rosnina et al. 2023; Haryuni et al. 2024), moderate doses were most effective. Overall, the combined application of biochar (10 t ha^{-1}) and eco-enzyme (22.5–30 ml) shows promise for enhancing sweet potato sensory quality.

4. CONCLUSION

Application of rice husk biochar at 5–10 tons ha^{-1} significantly increased sweet potato tuber number and tuber fresh weight per tuber, while its effects on tuber length, tuber diameter, chlorophyll content, and fresh weight per plant remained numerically higher but statistically non-significant under the present conditions. Eco-enzyme application at 22.5–30 ml per plot increased primary branch count and tuber weight, while the highest concentration (30 ml) sometimes decreased individual tuber weight compared to 22.5 ml. Overall, these results indicate that moderate biochar and eco-enzyme rates can improve specific growth, yield components and tuber quality, but further research on higher doses and multi-season is necessary to optimize sweet potato productivity in field setting.

5. ACKNOWLEDGEMENT

Authors thank the Department of Agroecotechnology for their support in making this study possible, and sincere thank you to Dewi Sartika Aryani, one of our colleagues, for her constructive criticism of this manuscript.

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