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A Circular Bioresource Approach: Converting Water Hyacinth into Compost for Improved Soil Fertility and Yam Production in Tropical Wetlands

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ABSTRAK/ABSTRACT

Pendekatan bioresource sirkular: Konversi eceng gondok menjadi kompos untuk meningkatkan kesuburan tanah dan produksi ubi di lahan basah tropis

Ekosistem lahan basah tropis menghadapi tantangan akibat tanah yang asam, drainase yang buruk, dan fluktuasi tingkat air, yang membatasi kesuburan tanah dan produktivitas pertanian. Namun, biomassa eceng gondok (*Eichhornia crassipes*) yang melimpah menawarkan sumber daya organik in-situ yang dapat didaur ulang melalui pengomposan, mendukung pendekatan sirkulasi hara dengan mengembalikan unsur hara dari lingkungan perairan ke tanah pertanian. Penelitian ini bertujuan untuk mengevaluasi pengaruh kompos eceng gondok terhadap sifat kimia tanah dan hasil ubi air Alabio (*Dioscorea alata* L.) yang dibudidayakan pada lahan rawa lebak tropis. Kompos eceng gondok dengan rasio C/N sebesar 15,55 diaplikasikan pada tiga dosis, yaitu 30, 35, dan 40 ton/ha menggunakan rancangan acak kelompok. Sifat kimia tanah dan hasil umbi dianalisis menggunakan uji ANOVA dan uji lanjut LSD, sedangkan analisis regresi digunakan untuk mengidentifikasi faktor utama yang mempengaruhi hasil. Hasil penelitian menunjukkan bahwa aplikasi kompos secara signifikan meningkatkan N-total, P-total, P-tersedia, C-organik, dan kapasitas tukar kation tanah. Hasil umbi tertinggi sebesar 7,4 kg/m² diperoleh pada dosis kompos 40 ton/ha, meningkat 21% dibandingkan dosis terendah. Analisis regresi (R^2 = 0,904) menunjukkan bahwa fosfor tersedia tanah merupakan faktor utama yang mempengaruhi peningkatan hasil. Hasil ini menunjukkan bahwa kompos eceng gondok berpotensi meningkatkan kesuburan tanah dan produktivitas ubi air pada sistem pertanian lahan basah tropis melalui pemanfaatan biomassa gulma secara berkelanjutan.

Keywords:
Circular bioeconomy, *Dioscorea alata*, Freshwater swamp, Phosphorus availability, Sustainable agriculture

Tropical wetland ecosystems face challenges due to acidic soils, poor drainage, and fluctuating water levels, limiting soil fertility and agricultural productivity. However, the abundant biomass of water hyacinth (*Eichhornia crassipes*) offers a potential in-situ organic resource that can be recycled through composting, supporting a circular nutrient approach by returning nutrients from aquatic environments to agricultural soils. The objective of this research was to evaluate the effects of composted water hyacinth on soil chemical properties and crop performance of the Alabio water yam (*Dioscorea alata* L.) grown in tropical freshwater swamps. Water hyacinth compost with a C/N ratio of 15.55 and enriched with essential nutrients was applied at three rates: 30, 35, and 40 ton/ha, using a randomized block design. Soil chemical properties and tuber yield were analyzed by ANOVA and LSD tests, and regression analysis was performed to identify the key factors influencing yield. The compost significantly improved soil total-N, total-P, and available-P, while increasing soil organic-C and cation-exchange capacity. The highest tuber yield, 7.4 kg/m², was obtained at the 40 ton/ha compost rate, representing a 21% increase compared with the lowest rate. Regression analysis (R^2 = 0.904) confirmed that soil available phosphorus was the primary determinant of yield improvement. This research provides empirical evidence that water hyacinth compost amendment can simultaneously enhance soil fertility and yam yield in tropical wetland systems.

INTRODUCTION

Wetland areas are ecologically critical landscapes characterized by hydromorphic soils and fluctuating water levels. These areas play essential roles in mitigating flood risks, preserving freshwater resources (Ferreira *et al.*, 2023), and supporting biodiversity and local economies (Alikhani *et al.*, 2021). It is generally characterized by acidic conditions and poor drainage, which together influence soil fertility and nutrient dynamics. High soil acidity can reduce nutrient availability and increase the solubility of elements such as aluminum and iron, thereby limiting plant growth and agricultural productivity (Géant *et al.*, 2025). In addition, limited aeration and fluctuating water regimes affect microbial activity and nutrient transformation processes, further influencing soil fertility status. These conditions require appropriate soil management strategies to maintain and improve agricultural productivity in wetland agroecosystems. One potential approach involves the utilization of in-situ biomass resources, particularly invasive aquatic weeds such as water hyacinth (*Eichhornia crassipes*).

The rapid growth of water hyacinth negatively impacts water quality (Mitan, 2019), promotes siltation, and disrupts aquatic life (Dersseh *et al.*, 2022). Local farmers have attempted to control the proliferation by using the plant as green manure (freshly applied), but this practice has several limitations, including slow nitrogen (N) mineralization and potential carbon © loss (Begum *et al.*, 2021). Composting water hyacinth offers a promising alternative, transforming this invasive plant into a valuable organic fertilizer rich in essential nutrients such as N phosphorus (P), and potassium (K) (Gezahegn *et al.*, 2024), enhance soil health and soil structure, maintain soil water and nutrient availability for plant uptake (Ho *et al.*, 2022), and organic-C content (Jindo et al., 2016). However, the effectiveness of organic amendments derived from aquatic biomass in modifying the chemical characteristics of freshwater swamp soils remains a relevant issue in the context of sustainable soil management. A clearer understanding of how compost derived from water hyacinth contributes to improving soil fertility parameters is essential for optimizing the utilization of locally available biomass resources and enhancing the productivity of swamp-based agricultural systems.

During the dry season, freshwater swamps recede, allowing farmers to cultivate a variety of crops, including yams, which are an important alternative food source in tropical and subtropical regions (Oliveira *et al.*, 2021). In Indonesia, the Alabio water yam (*Dioscorea alata* L.) is a significant local cultivar adapted to freshwater swamp environments. This species provides a critical carbohydrate source for surrounding communities. According to a previous study, water yam provides essential nutritional sources that support food security (Washaya et *al.*, 2016). However, crop growth and productivity in wetland agroecosystems are often constrained by low soil fertility. These constraints can restrict nutrient uptake and plant development, resulting in suboptimal yield performance in yam cultivation under wetland conditions.

Therefore, this study approaches the management of invasive aquatic biomass from a resource-recycling perspective by integrating invasive-species utilization with soil fertility improvement in wetland agroecosystems. Water hyacinth accumulates substantial amounts of nutrients from aquatic environments, and its conversion into compost provides nutrients to agricultural soils. In acidic freshwater swamp soils, where nutrient availability and retention often limit crop productivity, the incorporation of water hyacinth-derived organic amendments may influence key soil chemical properties. To quantify these effects, this study evaluated the impact of different application rates of water hyacinth compost on soil chemical properties and tuber yield of Alabio water yam, a locally adapted cultivar cultivated in tropical freshwater swamp systems.

MATERIALS AND METHODS

Location and Time of Research

The study was carried out in the freshwater swamp area of North Hulu Sungai Regency, South Kalimantan Province, Indonesia (Figure 1). This area is annually submerged for 4–6 months and categorized as a middle freshwater swamp. The study was conducted during the dry season from July to December 2021.

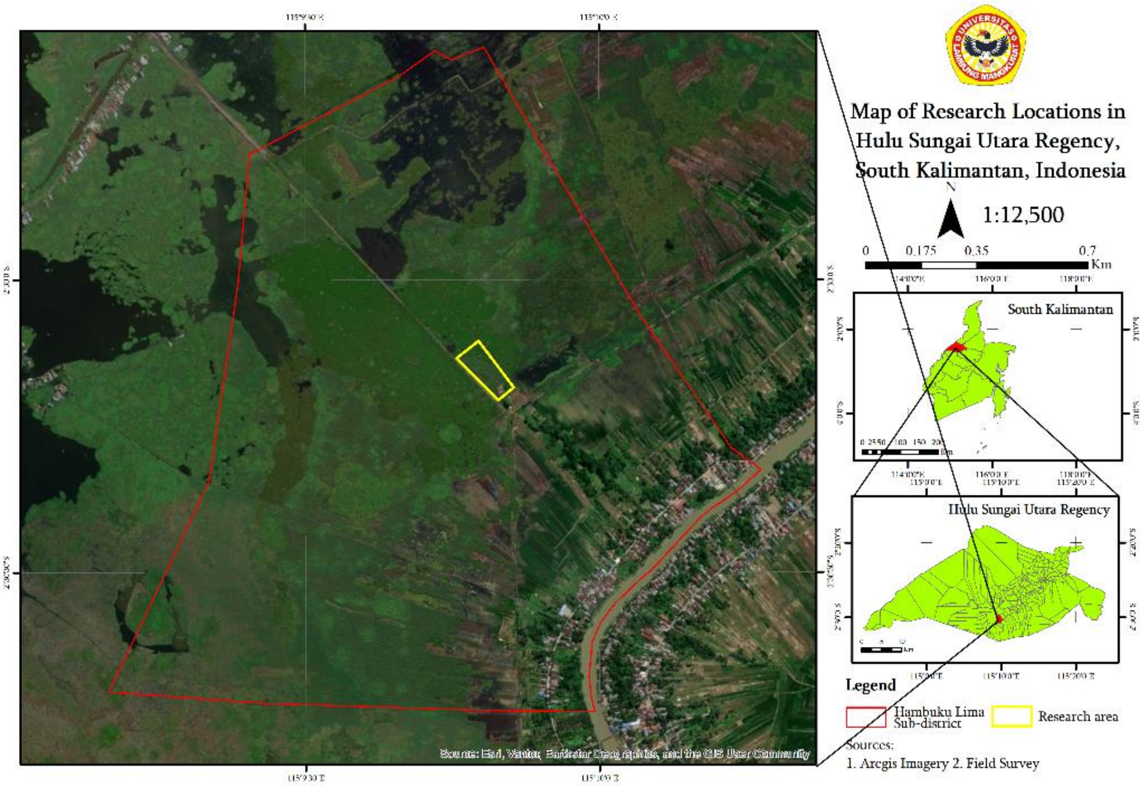

Figure 1. Research location

Experimental Design

A randomized block design was used in this study. The experiment consisted of seven blocks, each containing three plots representing different application rates of water hyacinth compost, namely 30, 35, and 40 ton/ha. Each plot measured 1×7 m. Yam plants were spaced 50×50 cm, while the distance between plots was 0.5×7 m.

Compost Production and Characterization

The compost was prepared by chopping water hyacinth and sun-drying for three days to reduce the moisture content. Approximately 300 kg of dried water hyacinth (water content 52%) was mixed with 75 kg of rice bran, 50 kg of cow manure, and 25 L of decomposer was added. The decomposer used in this study was a commercial microbial consortium (EM4) containing fermentation microorganisms (*Lactobacillus* and *Saccharomyces*), N-fixing bacteria, P-solubilizing bacteria, hormone-producing microorganisms, and organic matter-decomposing microbes (cellulolytic and ligninolytic). The composting process lasted 21 days, with materials turned every two days. Mature compost typically exhibits a dark brown to black color, an earthy odor, and a crumbly structure

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(Pirsaheb *et al.*, 2025). The chemical analysis of the mature compost was conducted to determine the content of total-N, total-P, total-K, organic-C, carbon to nitrogen ratio (C/N), as well as the presence of heavy metals, including lead (Pb) and cadmium (Cd). All parameters were analyzed following the method outlined by Zhao *et al.* (2025).

Water Yam Cultivation

The planting material used in this study was Alabio yam cultivar Habang Harum (fragrant red). Stem cuttings were obtained from healthy and physiologically mature mother plants grown by local farmers in the study area. Each cutting measured approximately 2–3 cm in length and contained 1–2 nodes.

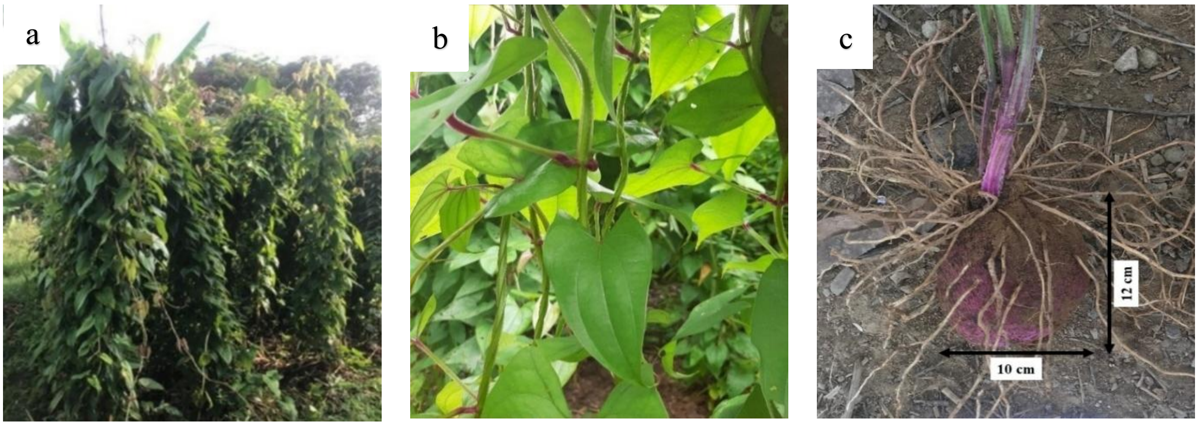

Figure 2. Habang Harum cultivar of Alabio water yam. (a) The whole plant, (b) the stem and leaves, and (c) the yam.

The experimental field was first cleared of existing vegetation and plant residues. Land clearing was carried out manually using simple agricultural tools. After clearing, the swamp land was prepared by draining excess water temporarily. The prepared land was then divided into seven experimental blocks. The compost was applied at the designated rates according to the treatment and incorporated into the soil by mixing uniformly into the topsoil of each experimental plot one week before planting. Regarding fertilization, no inorganic fertilizer was applied during the experiment. During crop establishment, routine field maintenance such as weeding, replanting, drainage management, and pest control was carried out uniformly across all treatments. The wooden stakes were installed to support the climbing growth of the plants after 4 weeks of planting. Harvesting occurred earlier than planned due to rising soil water levels.

Soil Analysis

The chemical analysis of the soil was conducted on soil samples before and after the study was completed. Soil samples were collected from a depth of 0–15 cm before planting and after harvest. Three subsamples (200–250 g each) were mixed, air-dried, sieved (⌀2 and 0.5 mm), and analyzed for chemical properties. Gravel, leaves, and roots were removed before analysis. Soil texture was determined using the Bouyoucos method (Orhan & Kılınç, 2020) and pH was measured using a 1:5 soil-to-deionized-water ratio. N-ammonium ($N\text{-}NH_4^+$), N-nitrate ($N\text{-}NO_3^-$), total-P and total-K were extracted with KCl (1 N) and H_2SO_4 (96%), then measured spectrophotometrically (Ma *et al.*, 2020). Total-N was measured using the Kjeldahl method (Gautam *et al.*, 2023), and organic-C was determined with the Walkley-Black method (Enang *et al.*, 2018). Cation exchangeable capacity (CEC), soluble iron (Fe), and exchangeable cations (Ca, Na, K, Mg, and Al) were extracted with $NH_4CH_3CO_2$ (1 N, pH 4.8) (Kabala & Jedrzejewski, 2024).

Data Analysis

Statistical analyses were performed using Genstat 11th edition. Homogeneity of variance was tested using Bartlett's test, and non-homogeneous data were transformed using the square root method. One-way analysis of variance (ANOVA) was conducted, and significant differences among treatments were evaluated using the Least Significant Difference (LSD) test at a 95% significance level. Screening factor analysis results on soil properties using standardized stepwise regression was also conducted.

RESULTS AND DISCUSSION

Water Hyacinth Compost Quality

The chemical composition of the water hyacinth compost (Table 1) demonstrated characteristics of a mature and nutrient-rich organic amendment. The compost contained pH 7.6, moisture content 49.7%, total-N of 1.43%, total-P of 2.62%, total-K of 0.56%, and organic-C of 22.63%, with a C/N ratio of 15.55. These values fall within the recommended range for high-quality compost (C/N ≤ 25; organic-C ≥ 15%) and indicate advanced decomposition and potential for rapid nutrient mineralization. The heavy metal concentrations were below critical limits (Pb 14.78 ppm; Cd < 0.001 ppm), confirming the compost's safety for agricultural use.

The relatively high phosphorus content compared with typical farmyard manure (≈ 1.3%) highlights the potential of water hyacinth compost as a P-rich input. In addition, the balanced macronutrient composition supports both immediate nutrient supply and long-term soil fertility, making it suitable for wetland soils that often exhibit low N and P availability.

Table 1. Chemical properties of water hyacinth compost

Parameters	Value	Standard*
pH	7.6	4-9
Water content (%)	49.7	8-20
Total-N (%)	1.43	≥ 2
Total-P (%)	2.62	≥ 2
Total-K (%)	0.56	≥ 2
Organic-C (%)	22.63	≥ 15
C/N	15.55	≤ 25
Pb (ppm)	14.78	≤ 50
Cd (ppm)	<0.001	≤ 2

Note: * Standard value based on Decree of Minister of Agriculture of the Republic of Indonesia (2019) No. 261/KPTS/SR.310/M/4/2019

The water hyacinth compost used in this study demonstrated nutrient characteristics consistent with high-quality organic amendments. Its relatively low C/N ratio (15.55) and high organic-C content (22.63%) indicate advanced decomposition and high mineralization potential, supporting rapid nutrient release after application. The total-P content (2.62%) was notably higher than most agricultural composts reported by Singh & Kalamdhad (2015), highlighting the phosphorus-rich nature of water hyacinth biomass. The very low concentrations of Pb and Cd confirmed the compost's safety for agricultural use, which is a critical factor for sustainable soil management in wetland-based production systems.

The macronutrient balance of compost supports both immediate nutrient availability and long-term soil fertility. Such composition is advantageous in tropical wetland soils, which are typically low in available N and P due to anaerobic conditions and high Fe–Al activity that immobilizes phosphate. The results emphasize that compost derived from invasive aquatic biomass can serve as a sustainable nutrient source for low-fertility hydromorphic soils.

Initial Soil Properties

The experimental soil was characterized as silty clay loam with slightly acidic reaction (pH 5.12), moderate cation-exchange capacity (25.03 cmol/kg), low levels of organic-C (1.50 %), low levels of available-P (2.4 mg/kg) and total-N (0.16 %) (Table 2). The base-saturation percentage (53.02 %) indicates medium fertility status typical of tropical freshwater swamps. The initial soil properties confirmed a generally low nutrient status, justifying the application of organic amendments to improve fertility.

Effect of Compost Application on Soil Chemical Properties

This study was designed to compare different application rates of water hyacinth compost under wetland cultivation conditions to identify the most suitable rate for improving soil chemical properties and yam yield. For this reason, the experiment focused on comparisons among compost application levels rather than including a treatment without compost application. Water hyacinth compost significantly influenced several soil chemical properties (Table 2). Application rates of 30, 35, and 40 ton/ha produced clear improvements in soil fertility indicators. Total-N increased from 0.15% to 0.21% as compost rate rose from 30 to 40 ton/ha, representing a 40% improvement ($p < 0.05$). Total-P rose markedly from 43.68 to 56.66 % (30% increase), while available-P increased by 83% (from 2.06 to 3.77 mg/kg). These increases demonstrate the compost's capacity to enhance nutrient availability in wetland soils. Soil pH remained relatively stable (5.40–5.48), indicating that compost application did not alter soil acidity significantly.

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Table 2. Soil chemical properties of before (initial soil) and after treated soil with different rates of water hyacinth compost (after growing the yam).

Parameters	Before the experiment	Value of each parameter following water hyacinth compost treatment (ton/ha)		
		30	35	40
Texture	Silty Clay Loam	-	-	-
pH	5.12	5.44 ± 0.15	5.4 ± 0.41	5.48 ± 0.33
CEC (cmol/kg)	25.03	28.22 ± 2.03	27.67 ± 2.99	30.96 ± 0.78
Organic-C (%)	1.50	1.65 ± 0.30	1.79 ± 0.25	1.86 ± 0.19
C/N	9.38	11.07 ± 0.2b	11.19 ± 0.31b	8.86 ± 0.31a
Base saturation (%)	53.02	57.42 ± 7.82	59.35 ± 17.52	62.33 ± 10.37
Macronutrients				
Total-N (%)	0.16	0.15 ± 0.03a	0.16 ± 0.02a	0.21 ± 0.03b
Total-P (%)	58.13	43.68 ± 1.21a	47.16 ± 2.26b	56.66 ± 6.73b
Total-K (%)	20.83	22.78 ± 0.63	23.54 ± 0.28	24.17 ± 1.36
Exchangeable-K (cmol/kg)	0.07	0.09 ± 0.01	0.09 ± 0.03	0.09 ± 0.02
$N\text{-}NH_4^+$ (mg/kg)	21.37	61.28 ± 15.48	65.4 ± 9.61	68.19 ± 11.51
$N\text{-}NO_3^-$ (mg/kg)	2.2	1.45 ± 0.23a	5.47 ± 0.73b	8.04 ± 0.96c
Available-P (mg/kg)	2.4	2.06 ± 0.50a	2.98 ± 0.96ab	3.77 ± 0.68b
Exchangeable-Ca (cmol/kg)	12.41	18.04 ± 2.50	14.25 ± 2.72	16.09 ± 3.05
Exchangeable-Mg (cmol/kg)	0.13	0.15 ± 0.10	0.18 ± 0.05	0.23 ± 0.10
Micronutrients				
Soluble-Fe (mg kg^{-1})	132.05	99.22 ± 64.20	115.89 ± 79.38	214.95 ± 91.78
Beneficial elements				
Exchangeable-Na (cmol/kg)	0.27	0.24 ± 0.06	0.18 ± 0.09	0.16 ± 0.02
Exchangeable-Al (cmol/kg)	1.99	1.25 ± 0.70	1.10 ± 1.28	1.95 ± 0.53

Note Mean values followed by the same letter in the same row are not significantly different based on the LSD test at a significant level of 5%

The ammonium ($N\text{–}NH_4^+$) content ranged from 61.28 to 68.19 mg/kg across treatments, while nitrate ($N\text{–}NO_3^-$) increased sharply from 1.45 to 8.04 mg/kg (Table 2). The five-fold increase in $N\text{–}NO_3^-$ reflected enhanced nitrification and N mineralization due to the compost's low C/N ratio. Although $N\text{–}NH_4^+$ remained the dominant form, its coexistence with increasing $N\text{–}NO_3^-$ indicates improved N cycling efficiency. The observed increase in total-N and $N\text{–}NO_3^-$ concentrations with higher compost application rates demonstrates the role of the amendment in improving soil N availability. The dominance of $N\text{–}NH_4^+$ over $N\text{–}NO_3^-$ across treatments aligns with previous reports indicating that acidic and waterlogged soils favor ammonium retention due to reduced nitrification activity (Li *et al.*, 2018). The low C/N ratio of the compost facilitated the mineralization of organic-N into inorganic forms, ensuring a sustained release of N during the yam growth period. At the 40 ton/ha rate, the mineral N pool was substantially higher, showing that water hyacinth compost can act as both a nutrient source and a microbial stimulant. Araújo *et al.* (2020) noted that rapid mineralization enhances crop N uptake efficiency while minimizing gaseous losses, which is particularly relevant in wetlands with fluctuating redox conditions. Thus, integrating this compost into wetland agriculture could help mitigate N deficiency and stabilize nutrient cycling under tropical conditions.

Phosphorus availability increased markedly with compost application, particularly at the highest rate. The rise in total-P and available-P may be attributed to the presence of soluble organic acids during compost decomposition, which compete with phosphate ions for adsorption sites on Fe and Al oxides, thus enhancing desorption (Yang *et al.*, 2019). The significant correlation between available P and yam yield ($R^2 = 0.904$) confirms phosphorus as a key yield-limiting factor in these soils. Phosphorus is more directly involved in the biochemical processes of tuber formation, including energy transfer, starch synthesis, and hormonal regulation (Ahmad *et al.*, 2024). Although potassium is crucial for overall plant health and function, phosphorus plays the more essential role in driving tuber development and ensuring optimal growth of storage organs like tubers (Rutan & Steinke, 2026). These findings are consistent with Bhatt *et al.* (2019), who reported that organic amendments reduce P fixation and improve its bioavailability. The improvement in CEC and base saturation observed in this study further demonstrates the compost's role in enhancing nutrient retention and cation balance, promoting a more favorable soil environment for plant growth. In the context of tropical wetlands, where chemical fertilizers are often inefficient due to rapid nutrient losses, water hyacinth compost offers a slow-release and environmentally sound alternative.

Soil organic-C rose modestly from 1.65% to 1.86%, while CEC increased from 28.22 to 30.96 cmol/kg (≈ 10% gain) as compost rate increased. Base saturation followed a similar trend (57.24% → 62.33%), confirming overall fertility enhancement. These improvements suggest greater nutrient-retention capacity and reduced leaching losses in compost-amended soils. Soluble Fe concentration increased with higher compost application (99.22 → 214.95 mg/kg), reflecting the mobilization of Fe under reducing conditions common in swamp soils. The compost, rich in organic-C, stimulates microbial activity that promotes the reduction of Fe^{3+} to Fe^{2+}, a more soluble and bioavailable form of iron. This process is enhanced by the generally acidic nature of wetland soils, where low pH increases Fe solubility. Exchangeable Ca and Mg values were stable, ranging from 14–18 and 0.15–0.23 cmol/kg, respectively. Exchangeable Na and Al showed minor variations without significant differences ($p > 0.05$). The overall ionic balance remained favorable, supporting soil nutrient stability after compost addition.

The upward trend in soil organic-C and CEC across treatments reflects the contribution of compost-derived humic substances to the soil matrix. The increase in organic matter improves soil aggregation, aeration, and microbial habitat, leading to better nutrient cycling. Although the differences in SOC among treatments were not statistically significant, the consistent improvement indicates that compost application can stabilize C under alternating aerobic and anaerobic conditions typical of swamp soils (Zhao *et al.*, 2020). This stabilization process is important for maintaining soil fertility while contributing to climate-change mitigation through potential C sequestration. The increase in CEC from 28.22 to 30.96 cmol/kg supports the hypothesis that organic amendments improve nutrient buffering and minimize leaching losses—critical attributes in coarse-textured or periodically flooded soils.

Yield Response

Alabio water yam yield varied across the different rates of water hyacinth compost application, with a consistent trend of higher yield at increasing compost rates. The tuber yield was 22.7 ton/ha at water hyacinth compost application of 30 ton/ha, 25.2 ton/ha at 35 ton/ha water hyacinth compost application, and 27.5 ton/ha at 40 ton/ha water hyacinth compost application (Table 3). According to the LSD test at $p < 0.05$, compost rate significantly influenced crop productivity. The yield increase between the lowest and highest application rates represented a 21% improvement, demonstrating that higher compost input enhanced nutrient availability and tuber development. The growth performance of the Alabio wáter yam and one of its tuber harvested from the experiment plots were presented on Figure 3.

Table 3. Yield of Alabio water yam following treatment with water hyacinth compost application

Water hyacinth application (ton/ha)	Tuber yield (ton/ha)
30	22.7a
35	25.2b
40	27.5c

Note: Mean values followed by the same letter in the same row are not significantly different based on the LSD test at a significant level of 5%

The observed trend corresponds with the increases in total and available phosphorus in the soil (Table 3), indicating a strong nutrient–yield relationship. Regression analysis further confirmed this association, showing a highly significant positive correlation between soil available P and yam yield ($Y = 110.6 + 13.98$ Av-P; $R^2 = 0.904$). Phosphorus availability therefore emerged as the principal factor driving yield variation across treatments.

The significant yield improvement of the Alabio water yam under higher compost rates can be linked to enhanced nutrient supply, particularly phosphorus, and improved soil physical conditions. The regression model ($R^2 = 0.904$) emphasizes that phosphorus availability was the most influential factor in tuber production. This finding agrees with

Wu *et al.* (2017), who reported that adequate phosphorus promotes root expansion and energy metabolism, both essential for tuber growth.

Higher compost applications likely improved soil structure and nutrient retention, creating favorable rhizosphere conditions for yam root growth. The increased P availability supported enhanced energy transfer and root expansion, both of which are essential for tuber formation. These results clearly demonstrate that water hyacinth compost is an effective organic amendment for sustaining soil fertility and promoting crop productivity in tropical freshwater swamps. The yield increase under compost treatments demonstrates that organic amendments can substitute part of the inorganic fertilizer requirement, thus reducing production costs and environmental risks. Moreover, the integration of water hyacinth compost into local farming systems addresses two key challenges simultaneously: controlling invasive aquatic species and improving the productivity of underutilized wetland areas.

Figure 3. Alabio water yam grown on plot treated with water hyacinth compost (a), and tuber of the abalio water yam Habang Harum variety (b).

Research limitation

In addition to the key findings, it is important to note the limitations of this study. One limitation is the limited number of compost doses, which restricts the ability to assess the full range of effects on soil properties and yam yield. Future research could examine a wider range of compost application rates to explore the optimal dose for sustainable yam cultivation. Additionally, the study was conducted over a single growing season, and the long-term effects of compost on soil health and crop productivity should be explored in future multi-season studies. Other limitations include the lack of control over environmental factors such as rainfall and temperature, which may vary across growing seasons and affect results. Finally, the findings of this study are specific to swamp soils, further studies should investigate the effects of water hyacinth compost on different soil types to determine its broader applicability.

CONCLUSION

This study demonstrated that compost produced from the invasive water hyacinth is a highly effective organic amendment for yam cultivation in tropical wetland soils. The compost, characterized by a balanced nutrient composition, low C/N ratio, and negligible heavy-metal content, significantly improved key soil fertility indicators, including total-N, total and available-P, soil organic-C, and CEC. At the highest application rate of 40 ton/ha, the compost resulted in the most favorable soil properties and the highest yield of Alabio water yam (27.5 ton/ha), reflecting a 17.5% increase compared with the lowest application rate (22.7 ton/ha). Regression analysis (R^2 = 0.904) confirmed that available-P was the primary determinant of yield variation, emphasizing the essential role of P derived from the compost in enhancing nutrient uptake and supporting tuber development. The results align with the standards set by Minister of

Agriculture of the Republic of Indonesia Decree No. 261/KPTS/SR.310/M/4/2019, which outline the minimum quality requirements for organic fertilizers, confirming the compost's suitability as a soil amendment for improving soil fertility. Furthermore, the use of water hyacinth compost not only offers significant agronomic benefits but also provides an environmental advantage by mitigating the spread of this invasive species. This research contributes to the growing body of knowledge on sustainable agricultural practices, highlighting the potential of utilizing invasive aquatic biomass as an organic resource to improve soil health and boost crop productivity in tropical wetland ecosystems.

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