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Saswati Chakraborty[1,2*]
[1]Department of Oceanography, Techno India University, West Bengal, EM 4/1 Salt Lake, Sector V, Kolkata, India.
[2]Post Graduate Department of Zoology, Banwarilal Bhalotia College, G.T. Road, Asansol713303, West Bengal, India
*Corresponding author: msas5phd@gmail.com

Sufia Zaman
Department of Oceanography, Techno India University, West Bengal, EM 4/1 Salt Lake, Sector V, Kolkata, India.

Abhijit Mitra
Department of Oceanography, Techno India University, West Bengal, EM 4/1 Salt Lake, Sector V, Kolkata, India.

Correspondence:
Saswati Chakraborty*
Post Graduate Department of Zoology, Banwarilal Bhalotia College, G.T. Road, Asansol713303, West Bengal, India.*Corresponding author: msas5phd@gmail.com

Effect of Water Hyacinth-based Organic Fertilizer on the Soil Quality and Biomass of Mango Seedling

Saswati Chakraborty, Sufia Zaman, Abhijit Mitra

Abstract
Water hyacinth (*Eichhornia crassipes*), a highly invasive aquatic weed, poses significant ecological and economic challenges by clogging waterways and disrupting ecosystems. However, this study showcases the potential of converting this menace into a valuable resource using water hyacinth-based organic fertilizer (WHOF). The research highlights the positive impact of WHOF on soil health and the above-ground biomass (AGB) of mango seedlings. By applying WHOF in ratios of 1:1 and 1:4 with soil, alongside a control without WHOF, the best results for AGB and underlying soil health were observed with the WHOF: Soil = 1: 4 treatments. These findings underscore the importance of organic fertilizers as a sustainable alternative to chemical fertilizers, enhancing soil fertility and plant growth while addressing the water hyacinth problem in an environmentally beneficial way.

Keywords: Water hyacinth (*Eichhornia crassipes*), water hyacinth-based organic fertilizer (WHOF), above-ground biomass (AGB), mango seedlings.

1. Introduction
Water hyacinth (*Eichhornia crassipes*) is a menace to aquatic ecosystem. The persistent challenge of managing polluted water bodies has been exacerbated by the invasion of water hyacinth, a highly problematic aquatic plant that becomes difficult to eradicate once established. [8] While various control methods exist, their effectiveness often depends on site-specific factors and is frequently hindered by environmental conditions such as temperature and eutrophication. [14,20,22] The consistent failure of conventional methods to effectively eliminate water hyacinth underscores the need for sustainable alternatives that offer additional environmental benefits. [18,25,26,29] Utilizing water hyacinth to produce organic fertilizer presents a promising, eco-friendly control method that not only mitigates the spread of this invasive species but also serves as a natural plant growth enhancer.
The present research study was undertaken during the premonsoon season of 2024 to evaluate the potential of organic fertilizer produced from water hyacinth in promoting the growth of mango (*Mangifera indica*) plants at the seedling stage, with a particular focus on tracking both plant biomass and soil condition at the plantation site. The project aimed to achieve dual objectives: promoting plant growth and enriching soil quality while simultaneously addressing the ecological challenge posed by the invasive water hyacinth. This initiative commenced in March 2024 at a mango plantation in Raniganj, Jamuria, West Bengal.
The selected plantation site, characterized by moderate soil fertility and seasonal climatic fluctuations, provided a suitable environment for assessing the fertilizer's performance under natural conditions. The organic fertilizer was prepared through composting harvested water hyacinth mixed with other organic components (preferably cow dung), resulting in a nutrient-rich compost. Uniform-sized mango (*M. indica*) seedlings were planted, and the experiment included plots treated with the water hyacinth-based organic fertilizer (WHOF) alongside control plots managed with conventional farming methods.
The plants were regularly monitored to assess above-ground biomass along with soil health in terms of soil N, P, K, and SOC. The findings revealed significant improvement in plant growth and soil quality, particularly at a 1:4 ratio of organic fertilizer to soil. This ratio

demonstrated superior results compared to the 1:1 ratio and untreated control plots. Enhanced above ground biomass (AGB) of mango seedlings and a noticeable increase in soil nutrients were observed, validating the effectiveness of the WHOF.

2.Materials and Methods

2.1 Sample Collection and Compost Production

Fresh water hyacinth plants were manually collected from a nearby pond and processed for composting. The plants were sun-dried and cut into smaller pieces, measuring approximately 3–5 cm. Composting was conducted in a cemented chamber with the addition of an effective microorganism solution and sucrose to accelerate the process (Fig. 1). After a 40-day composting period, the resulting compost was analysed for its NPK content and other relevant parameters to assess its potential as an organic fertilizer.

Fig. 1: Composting of water hyacinth

2.2 Research Design

The prepared organic fertilizer was applied to 1-year-old mango seedlings in two ratios: 1:1 and 1:4 for organic fertilizer to soil. A control setup without application of organic fertilizer was maintained as a baseline for comparative analysis. The experiment spanned three months, from March to May 2024, with data collected at one-month intervals. This design enabled a thorough evaluation of the water hyacinth-based organic fertilizer's effects on mango seedlings and soil properties. Proxies such as above-ground biomass (AGB) of mango seedlings, soil nitrogen (N), soil phosphorus (P), soil potassium (K), and soil organic carbon (SOC) were assessed in every month across all three treatments as per the standard methodology. Kjeldahl method was used to measure soil nitrogen level, soil phosphorus was measured by extracting it with sodium bicarbonate depending on soil pH (usually alkaline). The extracted phosphorus reacts with molybdate and antimony reagents to form a phosphomolybdate complex. This complex is reduced to a blue colour using ascorbic acid, and its intensity is measured spectrophotometrically to quantify phosphorus, and potassium was measured using a flame photometer after extracting it with ammonium acetate. SOC was measured by Walkley and Black method (1934).

2.3 Statistical Analysis

The experiment's effectiveness was evaluated by monitoring key indicators, including above-ground biomass (AGB) and soil parameters (N, P, K, and SOC). Data collected during the study were analysed using ANOVA in SYSTAT software, with a significance level set at 0.05. This comprehensive statistical approach ensured robust and reliable insights into the impact of the organic fertilizer on plant growth and soil quality.

3. Result

The study revealed significant improvements in nitrogen (N) content when using water hyacinth-based organic fertilizer (WHOF) compared to the control. The WHOF : Soil ratios of 1:4 and 1:1 resulted in higher nitrogen levels, with the WHOF : Soil = 1:1 treatment showing the maximum increase (Fig. 2). This highlights the ability of WHOF to enrich soil nitrogen, which is crucial for plant vegetative growth and overall productivity.

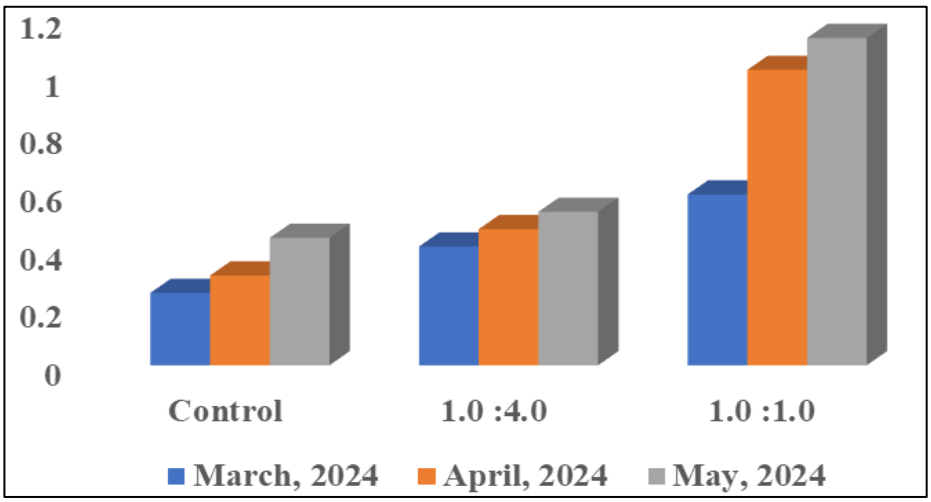

Fig. 2: Monthly variation of N (%) of WHOF

Phosphorus (P) levels also showed a substantial enhancement with WHOF application. The 1:4 and 1:1 ratios consistently outperformed the control, with the WHOF : Soil = 1:1 treatment achieving the highest phosphorus content (Fig. 2). This underscores the potential of WHOF to address phosphorus deficiencies, promoting root development and early plant growth.

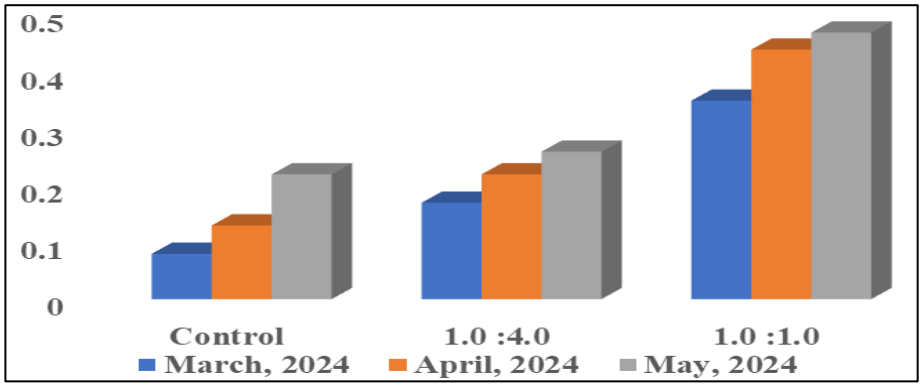

Fig. 3: Monthly variation of P (%) of WHOF

Similarly, potassium (K) content saw remarkable increases in the WHOF-treated soils. The WHOF: Soil = 1:4 and 1:1 treatment significantly elevated potassium level compared to the control, with the 1:1 ratio being slightly more effective (Fig. 4). Potassium is vital for plant water regulation and stress tolerance, making these findings particularly valuable for sustainable agricultural practices.

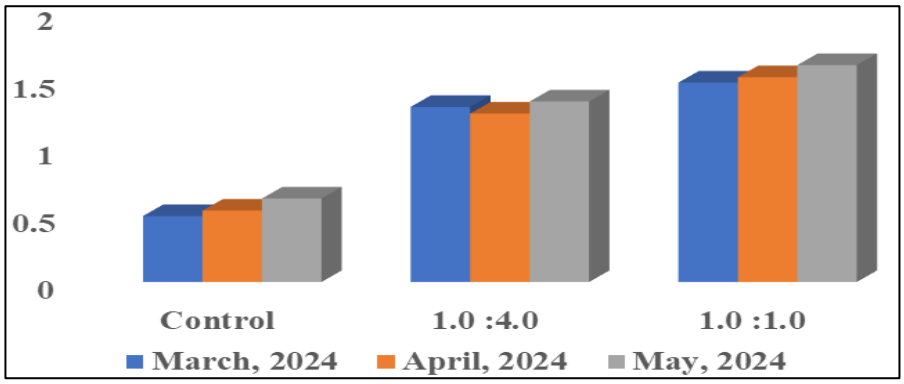

Fig. 4: Monthly variation of K (%) of WHOF

Soil organic carbon (SOC) also exhibited considerable improvement with WHOF application. The 1:4 treatment showed the highest SOC content, followed by the 1:1 ratio, both of which surpassed the control (Fig. 5). This indicates that WHOF not only enhances soil fertility but also contributes to better carbon sequestration, addressing environmental concerns while improving soil structure.

Above-ground biomass (AGB) of mango seedlings responded positively to WHOF application, with the WHOF: Soil = 1:4 treatment consistently showing the highest biomass across March, April, and May (Fig. 6-8). The WHOF: Soil = 1:1 treatment also demonstrated significant improvements over the control. The results suggest that WHOF is an effective organic amendment for promoting plant growth, offering a sustainable alternative to chemical fertilizers.

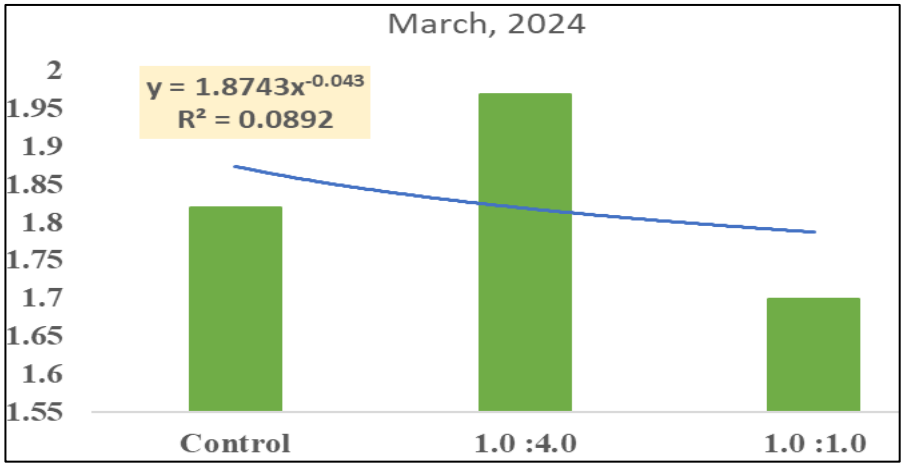

Fig 6: Growth of Mango seedling under different treatment in context to WHOF during March, 2024.

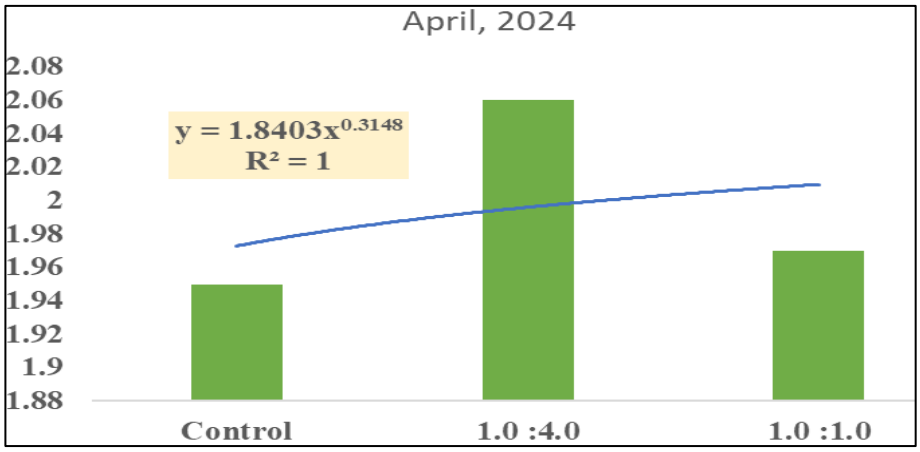

Fig 7: Growth of Mango seedling under different treatment in context to WHOF during April, 2024.

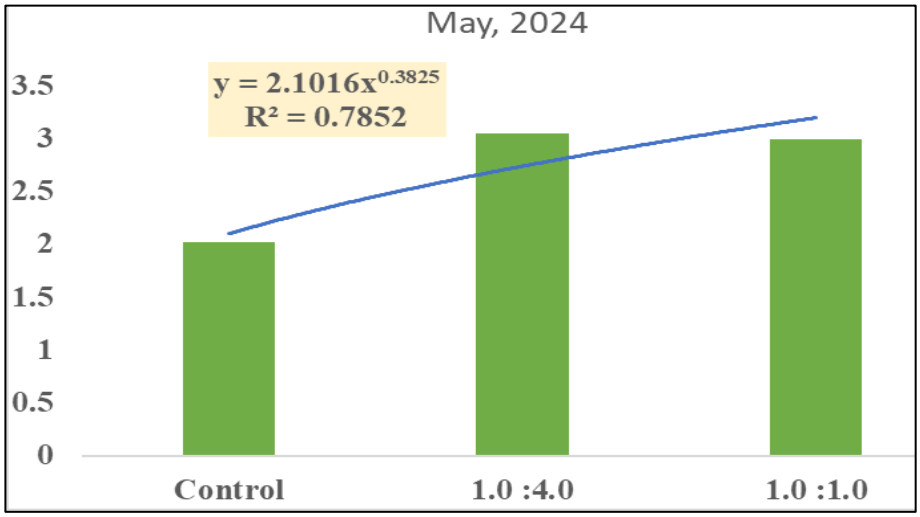

Fig 8: Growth of Mango seedling under different treatment in context to WHOF during May, 2024

4. Discussion

Water hyacinth is a highly invasive freshwater weed that has caused significant ecological and economic issues globally including in countries like India, Mexico, and South Africa. [1,9,13,28,31] To address this challenge, water hyacinth can be removed through mechanical extraction, biological, and chemical control methods. [2,3,6,12,17,21,30] Alternatively, it can be repurposed as a raw material for secondary products such as handicrafts, fibres, and fertilizers. [5,7,16,19,21,27]

We studied the N, P, K levels of fresh water hyacinth and documented values of 0.34% for N, 0.0017% for P and 0.019% for K. This is very similar to some earlier works where the N, P and K were 0.28%,0.001% and 0.016% respectively. We used the WHOF to monitor the biomass of the mango seedlings along with the health of the soil. The life cycle of mango (*Mangifera indica*) in India begins with the germination of seeds, typically during the monsoon season. The seedling stage is crucial, as young plants establish their root systems and grow rapidly under favourable conditions, requiring well-drained soil and consistent watering. Over the next few years, the tree matures, producing flowers that are pollinated to form fruit (Fig. 9). Mature trees bear fruit seasonally, with harvests typically occurring from March to June, depending on the region and variety.

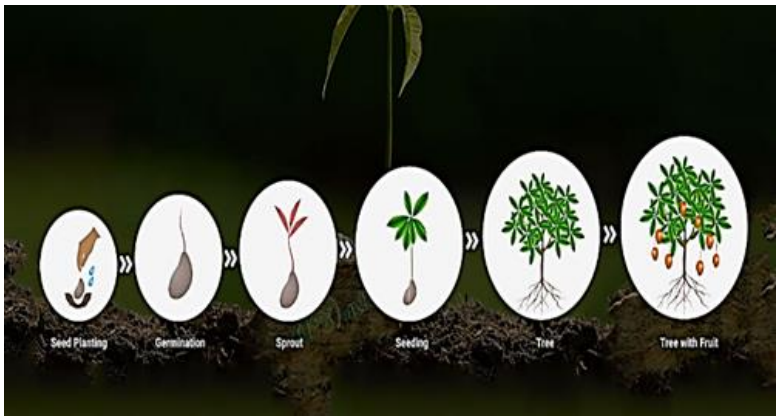

Fig. 9: Mango life cycle from seed to tree; our research focussed on the seedling phase from 1-year to 1-year 3months.

To determine the optimal dosage of WHOF, a dose optimization study was performed. In this experiment, a 1:4 fertilizer-to-soil ratio yielded significant positive effects on mango seedling growth, while higher doses (1:1) and controls showed limited impact. Notably, increasing the fertilizer dose beyond the 1:4 ratio did not result in further growth improvements and may even prove detrimental to plant development and soil quality. Hence, the 1:4 ratio represents the optimal dose for this WHOF preparation.

Interestingly, it is observed that at the ratio of WHOF: Soil =1:4 generated the best results with highest value of AGB and SOC irrespective of months.

Nitrogen, being essential for chlorophyll production, protein synthesis, and vegetative growth, contributes to the positive impact of WHOF on mango seedlings, as demonstrated in our research and by other studies. Interestingly, this beneficial effect has also been observed across various maize variants in Indonesia, including the Manado strain of yellow maize introduced in this research.[11] Thus, WHOF offers a sustainable solution to mitigate the water hyacinth invasion by transforming it into organic fertilizer. However, it appears most effective during the vegetative growth stage, with limited impact on the production stage.[7,10,15,23] Asadi et al., reported similar findings, noting that WHOF positively influenced the vegetative growth of lettuce (*Lactuca sativa*), where vegetative growth directly correlates with the crop's yield.[4]

5. Acknowledgement

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