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Nutrient restoration capacity of *Eichhornia crassipes* compost on a nutrient-depleted soil

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Abstract

Eichhornia crassipesis an invasive water plant that can cause severe problems to society and ecosystem in many parts of the world. This weed can withstand varied extreme environmental conditions in temperature, wind, humidity, illumination, acidity, alkalinity, and salinity. The probable means of combating its propagation and the various means of getting rid of this weed not proved much. This study investigated the potentials of E. crassipes in replenishing macronutrients specifically nitrogen, phosphorus and potassium (NPK) in a nutrient-depleted soil. Using an experimental study, water hyacinth was explored by comparing two conditions: i. the sundried compost; and ii. the fresh compost in soil. The composting lasted for 31 days, enough for the water hyacinth to decompose. The data gathered were then analyzed using single-factor analysis of variance (ANOVA). Results revealed that NPK improved from low to medium and high levels. Among sundried and fresh water hyacinth composts, there were significant effects in the nitrogen and phosphorous level in sundried treatment. Others do not have significant differences in NPK content before and after the composting, however all nutrient level means increased.

Keywords: Compost, Eichhornia crassipes, NPK, nutrient restoration, water hyacinth.

Introduction

The Threats and Opportunities from Water Hyacinth: *Eichhornia crassipes* or as well-known as water hyacinth is a fast growing aquatic plant which can endure varied ecological circumstances such as temperature, acidity, pH, salinity, etc.[1]. This elastic plant reproduce and disperse in a rapid manner even under unfavorable environmental situations that made it invade other species[2]. *Eichhornia crassipes* is a serious problem to the society and ecosystem in many parts of the world[3,4]. It is a noxious aquatic weed that pollutes all fresh water bodies and diminish the abundance of diversity of endemic species, thus reducing the genetic variability of organisms in the ecosystem[5]. Other environmental hazards and economic risks include obstruction of rivers, irrigation, and other water ways that causes flooding, an increase in transportation cost, and reduced fish catches[5,7]. These economic and ecological problems associated to water hyacinth are due its ease of reproduction and capacity to combat other aquatic organisms.

Despite of the problems caused by *Eichhornia crassipes,* scholars have identified some of its benefits. *E. crassipes* is recognized to produce attractive flowers and leaves being utilized in gardening[8]. It has been reported to be valuable in alternative medicine, sewage and water purification, fiber board and rope production, green manure, and mushroom bedding and compost material. Also, this plant is accounted for 64% of methane that may be extracted to produce biogas[8-11]. The weed can absorb nitrogen, phosphorus and potassium (NPK) from water and can be recommended to be used as primary material for composting[12]. A compost containing water hyacinth with manure and leaves hold N, P and K in about 2.2, 1.5, and 0.8%, respectively[13]. Water hyacinth is potentially high in terms of nitrogen supplement as 3.2% in its dry mass can be deposited[4,9]. These chemical characteristics of water hyacinth can generally provide macronutrients to soil when composted.

Required nutrients for plants: For a developing plant to grow properly, it must be able to absorb nutrients necessary for the process, namely; nitrogen, phosphorus, and potassium. Nitrogen is chemically combined with carbon, hydrogen, oxygen, and sulfur to construct biological building blocks of proteins which are amino acids. Proteins are essential in all life forms for it play a vital role in the survival of each organism. In plants reactions that involve enzymes require nitrogen. Phosphorous promotes the development roots, fruits, flowers, and seeds through assisting the entire plant in storing and transferring energy, thus it improves the quality of the plant. Finally, potassium regulates the water content of the plant through directing the opening and closing of the stomata[14]. Most of the nutrients needed by plants could be given by water hyacinth compost. Composting is the economical and best technique for disposal of organic waste and converts it in to valuable product[15].

Significance of the study: Composted *Eichhornia crassipes* may be utilized as fertilizers in an industrialized scale, due to the species' high rate of reproduction. The ease of acquisition of the weed would also affect the price of the fertilizer, making it very affordable to be loaned to farmers.

Aside from the capacity of the weed to be utilized in an industrialized scale, it may also be utilized in an individual scale, mostly by common people living beside waterways or with ease of access towards invaded areas. Common homeowners who seek cheap fertilizers for their personal utilization in their gardens may use the results of this study.

Persons of authority may find this study useful in a greater scale. Should they use this to inform their local constituents regarding the ways of utilizing the common weed that is *Eichhornia crassipes,* expected results would not only be the reduction of the weed from common waterways, but also the ease of aquatic transportation in areas severely affected by the invasion. This would greatly contribute to the efficiency of logistics personnel frequently hampered by the presence of the common water hyacinth.

Statement of the problem: The objective was to determine the soil nutrient restoration potentials of *Eichhornia crassipes* compost on a nutrient depleted soil.

This study also answered the following specific questions: i. What are the characteristics of the sundried and fresh of *E. crassipes* compost in terms of the nitrogen, phosphorous, and potassium level? ii. Are there significant differences on the characteristics of sundried and fresh *E. crassipes* compost in terms of the nitrogen, phosphorous, and potassium level?

Hypothesis: There are no significant differences in the characteristics of sundried and fresh *E. crassipes* composts in terms of nitrogen, phosphorous, and potassium content.

Materials and methods

Research design: This study is an experimental research, which is a systematic and scientific process wherein the researchers deliberately manipulate one or more independent variable/s that cause/s observable changes to the dependent variable. Changes were then recorded and compared to a standardized control. Extraneous or confounding variables which affect the dependent variable were regulated to prevent inconsistencies in the results of the experiment.

In this study, the independent variable that was manipulated is the different amounts of fresh and sundried water hyacinth applied to the compost. On the other hand, the dependent variables were the Nitrogen, Phosphorus, and Potassium content of the resulting composts. The dimensions of the containers were identical to prevent the confounding variables to affect the dependent variables that were measured.

Procedure: The researcher underwent specimen acquisition in the municipality of Malolos in Bulacan, Philippines, an area with a worsening situation regarding the *Eichhornia crassipes* invasion due to the prevalence of seasonal floods and stagnant waterways. After having the specimen authenticated by Mr. Danilo N. Tandang, Researcher II of the National Museum of the Philippines to be *Eichhornia crassipes*, the researcher obtained two (2) sacks of water hyacinths from the same spot to be utilized for this study. One sack of the acquired sample was sundried for ten (10) days.

Then the researcher proceeded to conduct soil testing in the 16 sampling sites located within the borders of La Consolacion University Philippines. After obtaining the necessary data regarding the macronutrient contents of each site, the researcher obtained 10 kilograms of soil from the site with the least macronutrient content. The evaluated nutrient level of the soil was low in nitrogen and phosphorus while deficient in potassium.

After sterilizing the soil to be utilized and waiting for the sun drying process to finish, the researchers then obtained another sack of fresh water hyacinth. This sample is to be cut up and composted while fresh, unlike the previous sample which was sundried.

With all the necessary materials, the researcher prepared the composts by placing it in a rectangular containers.

First, a negative control was set by putting 300grams of soil into the container and was labeled as A. Then, three sets of fresh water hyacinth compost mixture was conceptualized, and each set was triplicated for more precise results. Containers labeled with B were composed of 300grams of soil, 15grams of water hyacinth, and 0.6grams of carabao manure. Container C was composed of 300grams of soil, 30grams of water hyacinth, and 1.2grams of carabao manure. Finally, the fourth set was composed of 300grams of soil, 45grams of water hyacinth, and 1.8grams of carabao manure and was labeled with D.

For the sundried compost mixture, three sets were also hypothesized, and each set was also triplicated for more precise results. The measurement of the water hyacinth is an approximate assumption, putting into mind the loss of water from the sun drying process. For the first set, 300grams of soil was used, 15grams of water hyacinth, and 0.6grams of carabao manure.

The second set was composed of 300grams of soil, 30grams of water hyacinth, and 1.2grams of carabao manure. The third set was composed of 300grams of soil, 45grams of water hyacinth, and 1.8 grams of carabao manure.

Carbon and nitrogen sources have been considered by the researchers by following the preferred range of C:N ratio which was 25:1-30:1[16]. The 18 sets of compost were then left to decompose in the experimentation site located beside the university swimming pool of La Consolacion University Philippines. The site was covered with a tarpaulin sheet acting as a roof to prevent extraneous forces, like weather, to affect the results. The researchers regularly visited the site to provide moisture and aeration of the compost.

Final analysis was done after the stabilization period based on the, color and texture. It was done using the Soil Test Kit that was purchased from Bureau of Soils and Water Management.

For Nitrogen, testing of each compost sample was done first by filling up the 5mL test tube with soil sample up to the scratch mark. Then 24 drops of solution for Nitrogen test (N) were added. The test tube was swirled gently 30 times and was repeated after 5 minutes and allowed in the rack for 30 minutes. The color of the resulting solution on the top of the soil was matched with the color chart. The resulting Nitrogen solution was noted whether it is low, medium, or high.

For Phosphorous, testing of each compost sample was started with filling up the test tube with soil sample up to the scratch mark. Twenty four (24) drops of solution for Phosphorous Test (P) and four drops of solution for Phosphorous 1 (P1) were added. The test tube was swirled for about 1 minute and swirled again after 3 minutes. The test tubes were allowed to stand for 5 minutes. A stick in which one end was wrapped with foil or tin strip was prepared. The covered end part of the stick was used as the stirring rod.

The solution was slowly stirred for 1 minute without disturbing the soil. The previous step was repeated for about 2 minutes. Afterwards, the resulting solution of Phosphorus was matched with the colored chart and was noted whether it is low, medium or high.

For Potassium, testing of each compost sample was done by filling up the test tube with soil sample up to the scratch mark. Twenty four drops of solution for Potassium Test (K) and 8 drops of solution for Potassium 1 (K1) were added. The test tube was swirled gently for 1 minute and was repeated for 3 minutes. The test tube was allowed to stand until the soil particles are settled at the bottom. Afterwards, 12 drops of solution for Potassium 2 (K2) were added one drop at a time. Mixing and shaking of the test tube was advised to be avoided. The test tube was allowed to stand for 2 minutes.

The resulting appearance of the Potassium solution was observed whether the presence of a cloudy yellow on the top of the solution appeared. A distinct cloudy yellowish layer indicates that the soil has sufficient amount of Potassium. If there is no distinct yellowish layer on the top of the solution, the soil is deficient from Potassium.

Statistical analysis: The data on nutrient content specifically the nitrogen, phosphorous, and potassium level were statistically analyzed using One-way Analysis of Variance (ANOVA) technique. The level of statistical significance were all set to 0.05.

Results and discussion

Characteristics of the compost with sundried and fresh *Eichhornia crassipes*

Table-1: Summary of the Nitrogen Level of Sundried Water Hyacinth Treatments.

Treatments	Nitrogen level (Mean)	Qualitative Description
A	1.00	Low
B	2.33	Medium
C	3.00	High
D	2.33	Medium

Table-2: Summary of the Nitrogen Level of Fresh Water Hyacinth Treatments.

Treatments	Nitrogen level (Mean)	Qualitative Description
A	1.00	Low
B	1.67	Medium
C	1.67	Medium
D	2.33	Medium

The nitrogen level of the compost generally increased as shown in Tables-1 and 2. The mean levels of nitrogen provided by the sundried water hyacinth are higher compared to those of the fresh variety and this is due to the findings that fresh water hyacinth contain 0.4% N, while the water hyacinth, on a zero moisture basis, contains 1.5% N[17].

Table-3: Summary of the Phosphorous Level of Sundried Hyacinth Treatments.

Treatments	Phosphorous level (Mean)	Qualitative Description
A	1.00	Low
B	2.67	High
C	2.33	Medium
D	1.67	Medium

Table-4: Summary of the Phosphorous Level of Fresh Water Hyacinth Treatments.

Treatments	Phosphorous level (Mean)	Qualitative Description
A	1.00	Low
B	2.00	Medium
C	2.33	Medium
D	2.00	Medium

Based on the data presented in Table-3 and 4, the sundried water hyacinth provided more phosphorus levels to the compost compared to the fresh variety. This can be seen from the high yield of sundried setup, while all setups of fresh water hyacinth only go so far as medium yield when phosphorus is concerned. Andika, et al. found out that fresh water hyacinth contains 0.06% P_2O_5, on the other hand sundried water hyacinth can contain 7.0% P_2O_5.

Table-5: Summary of the Potassium Level of Sundried Hyacinth Treatments.

Treatments	Potassium level (Mean)	Qualitative Description
A	1.00	Deficient
B	1.67	Sufficient
C	2.00	Sufficient
D	1.67	Sufficient

Table-6: Summary of the Potassium Level of Fresh Water Hyacinth Treatments.

Treatments	Potassium level (Mean)	Qualitative Description
A	1.00	Deficient
B	1.67	Sufficient
C	1.67	Sufficient
D	2.00	Sufficient

Based on the data shown in Table-5 and 6, the potassium levels of both sundried and fresh water hyacinth after the composting process do not have differences in terms of the qualitative descriptions. Both yielded almost identical values, despite the other setup being sundried.

The data gathered has been surprising, especially as fresh water hyacinth contains 0.20% K_2O, while sundried water hyacinth contains 28.7% K_2O. Thus, the researchers expected a higher potassium yield for the sundried setups.

Significant differences on the characteristics of the compost with sundried and fresh of *Eichhornia crassipes:* Nitrogen is an essential element for plants to grow and develop properly. When this element is combined with other elements particularly C, H, O, and S, it could synthesize an amino acid which is a building block of proteins like enzymes. Enzymatic reactions in plants play a vital role to sustain photosynthesis[14].

Table-7: ANOVA of Means of Nitrogen Level of Sundried Water Hyacinth Treatments.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	6.33	3	2.11	12.67	0.0021	4.0662
Within Groups	1.33	8	0.167			
Total	7.67	11				

Table-7 shows the computed data of the analysis of variance in the nitrogen level of the different quantity of sundried water hyacinth compost. Having 12.67 as the computed F-value being greater than 4.0662 F-critical value would mean that there is a significant difference in nitrogen level in the soil in the different amount of sundried water hyacinth.

Table-8: ANOVA of Means of Nitrogen Level of Fresh Water Hyacinth Treatments.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.67	3	0.89	3.56	0.0672	4.0662
Within Groups	2	8	0.25			
Total	4.67	11				

Based on the Table-8, there is no significant difference on the nitrogen content on the different treatments of fresh water hyacinth. The F value is a little reduced than the F critical value, proving that the nitrogen yield of fresh water hyacinth is insignificant.

Table-9: ANOVA of Means of Phosphorous Level of Sundried Water Hyacinth Treatments.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.9167	3	1.6389	6.56	0.0151	4.06612
Within Groups	2	8	0.25			
Total	6.92	11				

Table-9 shows the computed data of the analysis of variance in the phosphorous level of the different amount of sundried water hyacinth compost. Having 6.56 in the F-value and being greater than 4.066181 in the F-critical value would mean that there is a significant increase in phosphorous level in the soil in the different amount of sundried water hyacinth. The null hypothesis was rejected due to a greater F value than the F critical value.

Table-10: ANOVA of Means of Phosphorous Level of Fresh Water Hyacinth Treatments.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3	3	1	3	0.095	4.06618
Within Groups	2.67	8	0.33			
Total	5.67	11				

The computed F value is lower than the F critical value which made the different quantity of fresh water hyacinth treatments insignificant.

Table-11: ANOVA of Means of Potassium Level of Sundried and fresh Water Hyacinth Treatments.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.583	3	0.52778	3.166 7	0.08545	4.0662
Within Groups	1.33	8	0.1667			
Total	2.9167	11				

Based on the computed data shown in Table-11, there are no significant differences on the potassium content on both fresh and sundried water hyacinth treatments. The amount of water hyacinth is not enough to significantly escalate the potassium in soil.

Conclusion

After all the processes of investigation were accomplished, the following were concluded: i. Generally, composting water hyacinth can increase the NPK content in soil. ii. Composting using sundried water hyacinth could restore a significant amount of nitrogen and phosphorous content in a nutrient-depleted soil. iii. This aquatic weed, above and beyond being a nuisance in nutrient-enrich bodies of water, is a low-cost alternative source of organic fertilizer in abundant supply. The weed is able to take up the nitrogen, phosphorous, and potassium from the water and can be used as a substrate in composting.

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