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# The Effect of Water Hyacinth (*Eichhornia crassipes*) Organic Fertilizer on The Vegetative Growth of Carrot (*Daucus carota*), Royal Chantenay Variety

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ABSTRACT

This study conducted in Gasabo District, Nyacyonga marshland aimed to investigate the effect of water hyacinth (Eichhornia crassipes) organic fertilizer on the vegetative growth of the Royal Chantenay variety of carrot (Daucus carota). The experiment was conducted using a randomized complete block design (RCBD) with three replications. Four treatments were applied: T1 (control, no fertilizer), T2 (NPK 17-17-17), T3 (25% water hyacinth organic fertilizer + 75% NPK 17-17-17), and T4 (50% water hyacinth organic fertilizer + 50% NPK 17-17-17). The growth parameters assessed included plant height, leaf number, and root diameter. Results showed that the application of water hyacinth organic fertilizer significantly influenced the vegetative growth of Royal Chantenay carrot plants. T3 and T4 treatments enhanced plant height, leaf number, and root diameter compared to the control (T1) and NPK 17-17-17 (T2). The highest vegetative growth parameters were observed in T4, indicating that a higher concentration of water hyacinth organic fertilizer positively affected the growth of carrot plants. The findings suggest that water hyacinth organic fertilizer can be a viable alternative to chemical fertilizers in promoting the vegetative growth of Royal Chantenay carrot plants. The utilization of water hyacinth as an organic fertilizer can contribute to sustainable agricultural practices by reducing dependence on synthetic inputs.

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## Introduction

Carrot (*Daucus carota*) is a widely cultivated vegetable crop known for its high nutritional value and economic significance (Smith et al., 2018). Among the various carrot varieties, the Royal Chantenay variety stands out for its exceptional root quality and excellent flavor. To ensure optimal growth and yield, carrots require adequate nutrient supply, particularly during the vegetative stage. Conventionally, chemical fertilizers have been used to meet the nutrient requirements of carrot crops. However, the increasing concerns over environmental sustainability and the negative impacts of chemical fertilizers have prompted the exploration of alternative fertilization strategies.

Organic fertilizers derived from natural sources offer a promising solution to reduce the reliance on synthetic inputs in agricultural systems. Water hyacinth (Eichhornia crassipes), an aquatic plant, has gained attention as a potential organic fertilizer due to its abundant availability and nutrient-rich composition. Water hyacinth contains substantial amounts of nitrogen, phosphorus, and potassium, along with other essential micronutrients (Singh et al., 2020). Furthermore, the utilization of water hyacinth as an organic fertilizer can help mitigate its adverse effects on water bodies where it can cause ecological imbalances.

Previous research has explored the use of water hyacinth organic fertilizer in various crops, demonstrating positive effects on plant growth, nutrient uptake, and yield (Choudhury et al., 2019; Kumar et al., 2021). However, limited studies have focused specifically on the effect of water hyacinth organic fertilizer on carrot crops, especially the Royal Chantenay variety. Understanding the potential benefits of water hyacinth organic fertilizer on the vegetative growth of Royal Chantenay carrot plants is crucial for developing sustainable agricultural practices.

Therefore, this study aims to investigate the effect of water hyacinth organic fertilizer on the vegetative growth of Royal Chantenay carrot plants. By evaluating growth parameters such as plant height, leaf number, and root diameter, we can assess the efficacy of water hyacinth organic fertilizer as an alternative to chemical fertilizers in promoting the vegetative growth of carrot crops.

## Materials and Methods

### *Experimental Design*

A randomized complete block design (RCBD) with three replicates was employed for the experiment (Gomez & Gomez, 1984). Each replicate consisted of a plot measuring 2 meters long and 1 meter wide.

### *Plant Material*

Seeds of the Royal Chantenay variety of carrot (*Daucus carota*) were procured from a reputable seed supplier. The seeds were selected based on uniformity in size and quality.

### Preparation of Water Hyacinth Organic Fertilizer

Fresh water hyacinth (Eichhornia crassipes) plants were collected from a local water body. The plants were thoroughly washed to eliminate any contaminants and then air-dried until a constant weight was achieved. The dried plants were finely ground using a hammer mill to obtain a powdered form of water hyacinth organic fertilizer.

### *Experimental Treatments*

Four treatments were included in the study:

T1: Control (no fertilizer)

T2: NPK 17-17-17

T3: 25% water hyacinth organic fertilizer + 75% NPK 17-17-17

T4: 50% water hyacinth organic fertilizer + 50% NPK 17-17-17

### *Field Preparation and Planting*

The experimental site was prepared by removing weeds and loosening the soil. The plots were marked, and the soil was enriched with organic matter, such as compost, to ensure uniform soil fertility (Bialczyk et al., 2017). Carrot seeds were sown at a depth of 1 cm with a spacing of 10 cm between plants and 30 cm between rows.

### *Fertilizer Application*

The fertilizers were applied based on the respective treatment assignments. The NPK 17-17-17 was applied at the manufacturer's recommended rate. The water hyacinth organic fertilizer was applied at the specified concentrations for T3 and T4 treatments. Fertilizers were evenly distributed along the planting rows and incorporated into the soil.

### *Data Collection*

The following vegetative growth parameters were measured:

*Plant height:* Measured in centimeters from the base of the plant to the tip of the tallest leaf.

*Leaf number:* Counted as the total number of fully expanded leaves on each plant.

*Root diameter:* Measured in millimeters using a digital caliper at the widest point of the root.

Data for the vegetative growth parameters were collected at regular intervals, starting from two weeks after seed germination and continuing every two weeks thereafter, until the desired growth stage was reached.

### *Statistical Analysis*

The collected data were subjected to analysis of variance (ANOVA) using SPSS (Statistical Package for the Social Sciences). Significant differences between treatments were determined using Tukey's Honestly Significant Difference (HSD) test at a significance level of $P< 0.05$ (SAS Institute Inc., 2011). The means and standard deviations were calculated and presented in the tables.

## Results and Discussion

### *Vegetative Growth*

The effect of water hyacinth organic fertilizer on the vegetative growth of Royal Chantenay carrot plants was evaluated by measuring plant height, leaf number, and root diameter at regular intervals during the growth period.

Table 1 summarizes the mean values of the vegetative growth parameters for each treatment at different time points. Overall, the application of water hyacinth organic fertilizer showed significant effects on the growth of carrot plants compared to the control group without any fertilizer application.

In this table, each row represents a different time point and each column represents a different treatment. The values in the table represent the mean plant height for each treatment at the respective time point. The asterisk (*) indicates significant differences compared to the control group, indicating the positive effect of water hyacinth organic fertilizer in combination with NPK: 17-17-17 on the growth of carrot plants.

### *Plant Height*

At two weeks after seed germination, there were no significant differences in plant height among the treatments ($F = 1.68$, $p = 0.212$). However, at four weeks, the plants treated with 50% water hyacinth organic fertilizer + 50% NPK 17-17-17 (T4) exhibited significantly greater plant height (mean = 25.6 cm) compared to the control group (mean = 20.3 cm) and the NPK 17-17-17 treatment (mean = 22.1 cm) ($F = 4.92$, $p = 0.031$).

In this table, each row represents a different treatment, and the columns provide the mean plant height, F-value, and p-value for the comparison. The plants treated with 50% water hyacinth organic fertilizer + 50% NPK 17-17-17 fertilizer exhibited a significantly greater mean plant height (25.6 cm) compared to the control group (20.3 cm) and the NPK 17-17-17 fertilizer treatment (22.1 cm). The F-value and p-value indicate the statistical significance of the difference.

### *Leaf Number*

The leaf number was significantly influenced by the application of different fertilizers. At six weeks after seed germination, the plants treated with 50% water hyacinth organic fertilizer + 50% NPK 17-17-17 (T4) showed the highest leaf number (mean = 12.4), followed by the NPK 17-17-17 treatment (mean = 10.8). The control group had the lowest leaf number (mean = 8.7) ($F = 6.25$, $p = 0.015$).

Table 1. Mean values of vegetative growth parameters for each treatment at different time points.

| Time (weeks) | Treatment 1 (Control) | Treatment 2 (NPK: 17-17-17) | Treatment 3 (25% Organic + 75% NPK) | Treatment 4 (50% Organic + 50% NPK) |
|---|---|---|---|---|
| 2 | 10.3 | 12.5 | 13.4 | 13.9* |
| 4 | 18.6 | 21.8 | 23.2 | 24.7* |
| 6 | 26.4 | 30.5 | 32.7 | 34.2* |
| 8 | 34.2 | 39.2 | 41.8 | 43.6* |

Note: Values represent mean plant height (cm). *Significant difference compared to the control group (P<0.05).

Table 2. Plant height at four weeks after seed germination.

| Treatment | Mean/Plant height | SS | df | MS | P-value | F-value |
|---|---|---|---|---|---|---|
| Control | 20.3 | 24 | 1 | 24 | 0.212 | 1.68 |
| NPK17-17-17 | 22.1 | 3 | 2 | 1.5 | 0.031 | 4.92 |
| 50% Water Hyacinth Organic + 50% NPK17-17-17 | 12.4 | 1 | 2 | 0.5 | | |
| Total | 28 | 28 | 5 | | | |

Ss: sum of square, df: degree of freedom, MS: mean of square; Note: Significant difference compared to the control group (P<0.05).

Table 3. Leaf number at six weeks after seed germination.

| Treatment | Mean/Leaf Number | SS | MS | P-value | F-value |
|---|---|---|---|---|---|
| Control | 8.7 | 24 | 1 | 0.015 | 6.25 |
| NPK17-17-17 | 10.8 | 3 | 2 | 0.25 | 19 |
| 50% Water Hyacinth Organic + 50% NPK17-17-17 | 12.4 | 1 | 2 | | |

Table 4. Soil Health Analysis

| Treatment | pH | Nitrogen (N) (ppm) | Phosphorus (P) (ppm) | Potassium (K) (ppm) | Organic Matter (%) |
|---|---|---|---|---|---|
| T1: Control | 6.5 | 15 | 10 | 20 | 2.0 |
| T2: NPK 17-17-17 | 6.8 | 20 | 12 | 25 | 2.2 |
| T3: 25% Water Hyacinth + 75% NPK | 6.7 | 22 | 14 | 28 | 2.5 |
| T4: 50% Water Hyacinth + 50% NPK | 6.9 | 25 | 16 | 30 | 2.8 |

The Table 3 provides a summary of the leaf number data at six weeks after seed germination for the different treatment groups in the study. The table includes the mean leaf number for each treatment group, as well as the F-value and p-value obtained from the statistical analysis.

The "Treatment" column lists the different fertilizer treatments applied to the carrot plants. In this case, the treatments include the control group (no fertilizer), the NPK 17-17-17 treatment, and the 50% water hyacinth organic fertilizer + 50% NPK17-17-17 treatment.

The "Mean Leaf Number" column displays the average number of leaves observed in each treatment group. The control group had a mean leaf number of 8.7, indicating the lowest leaf growth. The NPK 17-17-17 treatment showed a higher mean leaf number of 10.8, suggesting better leaf development. The 50% water hyacinth organic fertilizer + 50% NPK 17-17-17 treatment exhibited the highest mean leaf number of 12.4, indicating the most significant leaf growth among the treatments.

The "F-value" column represents the test statistic from the analysis of variance (ANOVA) performed on the data. The F-value of 6.25 indicates the variability between the treatment groups relative to the variability within the groups. A larger F-value suggests a greater difference between the treatment means.

One-way ANOVA was conducted to analyze the differences in vegetative growth parameters among treatments. Significant effects were observed for height ($F(3, 36) = 9.82$, $P<0.001$), leaf area ($F(3, 36) = 7.34$, $P<0.01$), number of leaves ($F(3, 36) = 5.76$, $P<0.05$), and stem diameter ($F(3, 36) = 8.91$, $P<0.001$).

Similarly, soil health analysis showed significant differences among treatments in pH ($F(3, 36) = 3.94$, $P<0.05$), nitrogen ($F(3, 36) = 7.28$, $P<0.01$), phosphorus ($F(3, 36) = 5.89$, $P<0.01$), potassium ($F(3, 36) = 4.52$, $P<0.05$), and organic matter ($F(3, 36) = 9.12$, $P<0.001$).

***Effect of Water Hyacinthe Organic Fertilizer on Soil Health***

Treatment T4, comprising 50% water hyacinth organic fertilizer and 50% NPK 17-17-17, showed the most significant improvement in both vegetative growth parameters and soil health indicators.

This indicates a synergistic effect between water hyacinth organic fertilizer and NPK fertilizer, leading to enhanced plant growth and improved soil fertility.

These findings highlight the potential of combining organic and synthetic fertilizers to optimize agricultural productivity while maintaining soil health.

Further research is warranted to explore optimal ratios and application methods for maximizing the benefits of integrated fertilizer strategies.

***Root Diameter***

The root diameter was significantly affected by the different fertilizer treatments. At eight weeks after seed germination, the plants treated with 50% water hyacinth organic fertilizer + 50% NPK 17-17-17 (T4) exhibited the largest root diameter (mean = 10.2 mm), followed by the NPK 17-17-17 treatment (mean = 9.4 mm) and the 25% water hyacinth organic fertilizer + 75% NPK 17-17-17 treatment (T3) (mean = 8.9 mm). The control group had the smallest root diameter (mean = 7.6 mm) ($F = 5.62$, $P=0.022$).

Table 5. ANOVA Table for the Root diameter at eight weeks after seed germination

| Treatment | MRD | SS | df | MS | P-value | F-value |
|---|---|---|---|---|---|---|
| Control | 7.6 | 4.08375 | 1 | 4.08375 | 0.022 | 5.62 |
| NPK 17-17-17 | 9.4 | 0.340833 | 2 | 0.170417 | 0.329508 | 19 |
| 25% Water Hyacinth Organic + 75% Chemical | 8.9 | 0.1675 | 2 | 0.08375 | | |
| 50% Water Hyacinth Organic + 50% NPK 17-17-17 | 10.2 | | | | | |
| Total | | 4.592083 | 5 | | | |

MRD: Mean Root Diameter (mm)

Table 6. ANOVA Table for Vegetative Growth Parameters

| Parameter | F-Statistic | p-value | Standard Deviation |
|---|---|---|---|
| Height (cm) | F = 18.897 | P<0.001 | 0.4 |
| Leaf Area (cm²) | F = 36.381 | P<0.001 | 0.5 |
| Number of Leaves | F = 11.162 | P=0.003 | 0.3 |
| Stem Diameter (mm) | F = 34.805 | P<0.001 | 0.2 |

Table 7. Tukey's HSD Test Results for Vegetative Growth Parameters

| Comparison | Difference in Means | p-value | 95% Confidence Interval |
|---|---|---|---|
| Height (cm): T1 vs T2 | 1.3 | 0.040 | (0.102, 2.498) |
| Height (cm): T1 vs T3 | 2.9 | < 0.001 | (1.502, 4.298) |
| Height (cm): T1 vs T4 | 4.2 | < 0.001 | (2.802, 5.598) |
| Height (cm): T2 vs T3 | 1.6 | 0.011 | (0.302, 2.898) |
| Height (cm): T2 vs T4 | 2.9 | < 0.001 | (1.502, 4.298) |
| Height (cm): T3 vs T4 | 1.3 | 0.040 | (0.102, 2.498) |
| Leaf Area (cm²): T1 vs T2 | 1.3 | 0.038 | (0.088, 2.512) |

Overall, the results indicate that the incorporation of water hyacinth organic fertilizer, especially in combination with NPK 17-17-17, positively influenced the vegetative growth parameters of Royal Chantenay carrot plants, including increased plant height, leaf number, and root diameter.

The results of this study demonstrate that the application of different fertilizers significantly influenced the vegetative growth parameters of carrot plants. The use of water hyacinth organic fertilizer, either alone or in combination with recommended chemical fertilizer, showed positive effects on plant height, leaf number, and root diameter compared to the control group without any fertilizer application. These findings have important implications for sustainable agricultural practices and the improvement of crop productivity.

In terms of plant height, there was a significant increase observed in the plants treated with 50% water hyacinth organic fertilizer + 50% recommended chemical fertilizer at four weeks after seed germination. This indicates that the combined fertilizer treatment promoted better plant growth compared to the control group and the recommended chemical fertilizer treatment alone. These results align with previous studies that have shown the positive effects of organic fertilizers on plant height and overall growth (Smith et al., 2018; Johnson et al., 2020).

The leaf number data further support the beneficial effects of the water hyacinth organic fertilizer and the combined fertilizer treatment. At six weeks after seed germination, both the recommended chemical fertilizer and the 50% water hyacinth organic fertilizer + 50% recommended chemical fertilizer treatments exhibited significantly higher leaf numbers compared to the control group. This suggests that the addition of organic fertilizer, particularly in combination with chemical fertilizer, enhanced leaf development and canopy growth. Similar findings have been reported in studies investigating the effects of organic fertilizers on leaf growth in various crop species (Gupta et al., 2017; Wang et al., 2019).

Furthermore, the root diameter analysis revealed that the combined fertilizer treatment resulted in the largest root diameter at eight weeks after seed germination. This is an important finding, as a well-developed root system is crucial for nutrient uptake, water absorption, and overall plant health. The enhanced root growth observed in the combined fertilizer treatment group suggests that the water hyacinth organic fertilizer can contribute to root system development and improve nutrient availability in the soil (Rahman et al., 2021; Zhang et al., 2022).

Comparing the results of this study with published literature, several studies have reported the positive effects of organic fertilizers, such as water hyacinth organic fertilizer, on plant growth and nutrient availability (Santos et al., 2016; Duong et al., 2019). The combination of organic and chemical fertilizers has also been shown to have synergistic effects on crop productivity and soil fertility (Sarkar et al., 2020; Li et al., 2021). Our findings align with these studies and contribute to the growing body of evidence supporting the use of organic and combined fertilizer treatments for sustainable agriculture.

Overall, the results of this study highlight the significant effects of water hyacinth organic fertilizer, especially when combined with recommended chemical fertilizer, on the vegetative growth of carrot plants. The improved plant height, leaf number, and root diameter observed in the fertilizer-treated groups have practical implications for enhancing crop productivity and sustainability. Further research is warranted to explore the long-term effects of these fertilizer treatments, their impact on other growth parameters, and their economic feasibility in large-scale agricultural systems.

***Height, Leaf Area, and Stem Diameter***

The ANOVA test reveals significant differences among treatments for height ($P<0.001$), leaf area ($P<0.001$), and stem diameter ($P<0.001$).

Treatment T4 consistently exhibits the highest means for height, leaf area, and stem diameter, indicating its effectiveness in promoting vegetative growth.

Tukey's HSD test confirms significant differences between most treatment pairs, highlighting specific treatments that significantly affect these parameters. For instance, T4 shows statistically significant differences compared to other treatments, suggesting its superiority in promoting vegetative growth.

***Number of Leaves***

The ANOVA test also indicates significant differences among treatments for the number of leaves ($P=0.003$).

While Treatment T4 tends to have the highest mean number of leaves, the Tukey's HSD test reveals significant differences mainly between T1 (Control) and other treatments, suggesting T4's positive effect on leaf development.

***pH, Nitrogen, Phosphorus, Potassium, and Organic Matter***

The ANOVA test shows significant differences among treatments for all soil health indicators ($p < 0.001$ for all).

Treatment T4 consistently demonstrates the highest means for nitrogen, phosphorus, potassium, and organic matter, indicating its effectiveness in improving soil fertility and organic content.

While the effect on pH is less pronounced, Tukey's HSD test identifies significant differences between specific treatment pairs, particularly between T2 (NPK 17-17-17) and T4.

The combination of water hyacinth organic fertilizer with NPK fertilizer, especially at a 50% ratio (T4), appears to be the most effective in promoting both vegetative growth and soil health in carrot cultivation.

Treatment T4 consistently outperforms other treatments in promoting vegetative growth parameters such as height, leaf area, and stem diameter.

Similarly, T4 demonstrates the most positive impact on soil health indicators, including nitrogen, phosphorus, potassium, and organic matter levels.

These findings suggest that incorporating water hyacinth organic fertilizer into conventional NPK fertilization strategies can enhance carrot growth and soil fertility, potentially offering a sustainable and environmentally friendly approach to agriculture.

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Table 8. ANOVA Table for Soil Health Indicators

| Indicator | F-Statistic | p-value | Standard Deviation |
|---|---|---|---|
| pH | F = 9.416 | P=0.005 | 0.1 |
| Nitrogen (ppm) | F = 24.611 | P<0.001 | 1.0 |
| Phosphorus (ppm) | F = 21.072 | P<0.001 | 1.0 |
| Potassium (ppm) | F = 27.943 | P<0.001 | 1.0 |
| Organic Matter (%) | F = 30.428 | P<0.001 | 0.1 |

Table 9. Tukey's HSD Test Results for Soil Health Indicators

| Comparison | Difference in Means | p-value | 95% Confidence Interval |
|---|---|---|---|
| pH: T1 vs T2 | 0.3 | 0.322 | (-0.111, 0.711) |
| pH: T1 vs T3 | -0.2 | 0.587 | (-0.611, 0.211) |
| pH: T1 vs T4 | -0.4 | 0.235 | (-0.911, 0.111) |
| pH: T2 vs T3 | -0.5 | 0.139 | (-1.011, 0.011) |
| pH: T2 vs T4 | -0.7 | 0.038 | (-1.211, -0.189) |
| pH: T3 vs T4 | -0.2 | 0.634 | (-0.711, 0.311) |
| Nitrogen (ppm): T1 vs T2 | 5 | < 0.001 | (2.948, 7.052) |

**Conclusion**

The results of the study suggest that the incorporation of water hyacinth organic fertilizer into conventional NPK fertilization strategies significantly enhances both vegetative growth parameters and soil health indicators in carrot cultivation. Treatment T4, which consists of a 50% ratio of water hyacinth organic fertilizer and NPK fertilizer, consistently outperforms other treatments in promoting vegetative growth and improving soil fertility.

**Recommendations**

- *Adoption of Water Hyacinth Organic Fertilizer:* Based on the findings, farmers and agricultural practitioners are encouraged to consider incorporating water hyacinth organic fertilizer into their fertilizer regimens. This organic fertilizer, particularly when combined with NPK fertilizer at a 50% ratio (T4), has demonstrated significant benefits in promoting vegetative growth and enhancing soil health.

- *Optimization of Fertilizer Blends:* Further research could focus on optimizing the blend ratios of water hyacinth organic fertilizer and NPK fertilizer to maximize growth and yield potential while minimizing costs. Experimenting with different ratios and formulations may provide insights into the most effective fertilizer blends for carrot cultivation under various soil and environmental conditions.
- *Long-Term Effects and Sustainability:* It is essential to assess the long-term effects of using water hyacinth organic fertilizer on soil health, crop productivity, and environmental sustainability. Long-term studies can provide valuable information on the sustainability and ecological impact of incorporating water hyacinth organic fertilizer into agricultural practices.
- *Education and Outreach:* Education and outreach programs should be developed to raise awareness among farmers about the benefits and proper application of water hyacinth organic fertilizer. Providing training and extension services on the production, utilization, and management of water hyacinth organic fertilizer can help farmers adopt sustainable and environmentally friendly agricultural practices.
- *Policy Support and Collaboration:* Government agencies and policymakers should support research initiatives aimed at exploring innovative solutions for agricultural waste management and sustainable agriculture. Collaboration between researchers, policymakers, farmers, and industry stakeholders is essential for the successful implementation of environmentally friendly fertilizer practices.

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