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Unveiling the Enigmas of Night Soil Composting: Boosting Carrot Length, Diameter, and Weight in Ruhango District, Southern Province, Rwanda.

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Abstract

This research investigated the efficacy of night soil composting as a sustainable agricultural practice to enhance carrot growth in Ruhango District, Southern Province, Rwanda. The study employed a Randomized Complete Block Design (RCBD) with four distinct treatments: local soil + night soil (T1), sandy soil + night soil (T2), local soil from the field (T3), and sandy soil only (T4 - Control). Each treatment was replicated four times to ensure robust statistical analysis.

The results demonstrated that treatments incorporating night soil (T1 and T2) consistently outperformed both the control group (T4) and local soil without night soil (T3). Carrots in T1 exhibited significant increases in length (23.5 cm), diameter (4.2 cm), and weight (82.5 grams). T2 also showed substantial improvements with mean values of 22.8 cm, 4.0 cm, and 80.7 grams for length, diameter, and weight, respectively. Treatment 3 (T3) provided modest growth enhancements compared to the control group, reinforcing the potential benefits of soil amendments. The control group (T4) represented baseline growth metrics.

In conclusion, night soil composting, particularly when integrated into local and sandy soils, emerged as a promising strategy to significantly enhance carrot production in Ruhango District. These findings offer valuable insights for sustainable agricultural practices, emphasizing the potential of night soil composting to improve crop yields and food security in similar agricultural regions. Further research and practical implementations are warranted to explore the scalability and long-term sustainability of this innovative approach.

Key Words: *Night Soil Composting, Carrot Growth, Sustainable Agriculture, Soil Amendments, Food Security, Ruhango District*

Introduction

Agriculture plays a pivotal role in Rwanda's economy, contributing significantly to food security, employment, and income generation (FAO, 2018). Among the various crops cultivated in the country, carrots (*Daucus carota*) stand out for their nutritional value and economic importance. Carrots are rich in essential vitamins, minerals, and dietary fiber, making them a vital component of the Rwandan diet (FAO, 2018). Furthermore, they represent a lucrative cash crop for smallholder farmers in the Ruhango District, located in the Southern Province of Rwanda (National Institute of Statistics of Rwanda, 2019).

Despite the significance of carrot production in Rwanda, farmers in Ruhango District, like many others across the nation, face several challenges that hinder their ability to maximize carrot yields. Soil fertility and nutrient management are prominent concerns in this region, particularly in the context of small-scale farming (Vanlauwe *et al*., 2011). Traditional farming practices often rely on limited external inputs, leading to nutrient depletion and reduced crop yields over time (Vanlauwe et al., 2010).

To address these challenges and unlock the full potential of carrot cultivation, there is a pressing need to explore innovative and sustainable agricultural practices (Vanlauwe *et al*., 2010). One such practice that holds promise is night soil composting. Night soil composting involves the controlled decomposition of human excreta and organic matter, resulting in a nutrient-rich fertilizer that can significantly enhance soil fertility and crop productivity (Thonart *et al*., 2002). This approach aligns with sustainable agriculture principles and offers a unique solution to the nutrient deficiencies commonly observed in the soils of Ruhango District (Thonart *et al*., 2002).

This research project aims to delve into the secrets of night soil composting and its potential to enhance carrot length, diameter, and weight in Ruhango District, Southern Province, Rwanda. By investigating the effects of night soil compost on carrot growth and yield, this study seeks to contribute valuable insights to the sustainable agriculture landscape in Rwanda (Vanlauwe *et al*., 2011). Through a combination of field experiments, soil analysis, and farmer participation, this research endeavors to establish evidence-based recommendations for the adoption of night soil composting as a viable and safe agricultural practice in the region (Vanlauwe *et al*., 2005).

Materials and Methods

Area of Research

The study was conducted in Ruhango District, located in the Southern Province of Rwanda. Ruhango District, established in 2005 by Law No. 29/2005 in Rwanda, encompasses an area of 626.8 square kilometers. It is bordered by the districts of Muhanga to the north, Nyanza and Nyamagabe to the south, Kamonyi and Bugesera to the East, and Karongi to the west. Situated on a plateau with low hills at an average elevation of 1500 meters, the district experiences a relatively high average temperature of 22 degrees Celsius and an average annual rainfall of 900 millimeters. The predominantly agricultural landscape features extensive farming on small, fragmented plots of land, with agriculture serving as the primary economic driver. Notably, the district benefits from substantial marshlands and the presence of the Nyabarongo and Akanyaru rivers.

Ruhango District, part of the Southern Province of Rwanda, is further divided into nine sectors, comprising 59 cells and 533 villages. The district is home to a population of 271,807 people, residing in 60,809 households, with 143,046 females and 128,761 males. The population density stands at approximately 415 individuals per square kilometer. (Gichangi *et al*,2018).

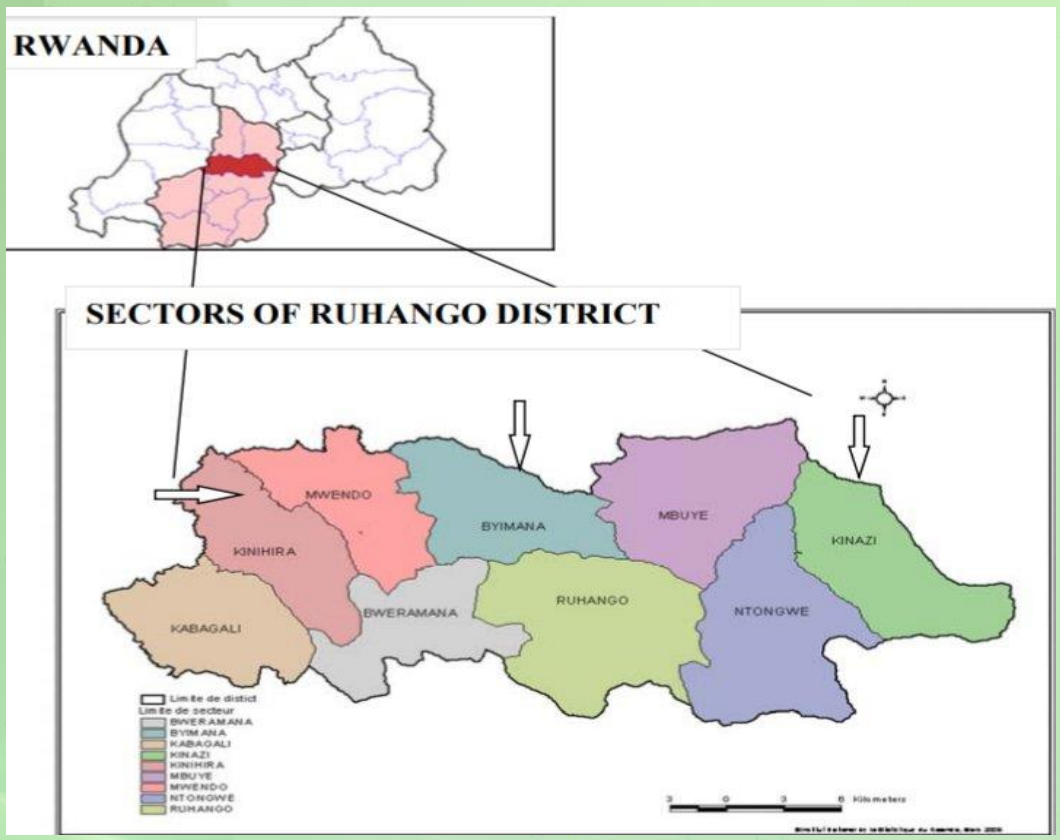

Figure 1. Administrative map of Ruhango District

Experimental Design

In our research, we adopted a meticulously planned Randomized Complete Block Design (RCBD) to investigate the influence of various soil treatments on carrot growth. We implemented four distinct treatments, each thoughtfully assigned to ensure robust statistical analysis and reliable results. Treatment 1 (T1) involved the combination of local soil with night soil, representing a composite soil treatment. Treatment 2 (T2) consisted of sandy soil mixed with night soil, offering another variation. Treatment 3 (T3) utilized unaltered local soil sourced directly from the field, providing a baseline for comparison. Lastly, Treatment 4 (T4), served as our control group, employing sandy soil without any additional amendments. The replication of these treatments within the RCBD framework allowed us to effectively control for spatial variations and assess the true impact of night soil composting on carrot growth. This design ensured that our research yielded statistically significant and reliable findings, shedding light on the efficacy of night soil composting in the context of our study.

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Soil Preparation

Before commencing the experiment, the soil used in each treatment was meticulously prepared to ensure consistency and accuracy (Amoah *et al*,2007). Sandy soil and local soil from the field were obtained and characterized to understand their initial properties. Control Group (T4): Sandy soil, representing the control group, was directly utilized without any alterations, Local Soil (T3): The unmodified local soil, sourced from the field, was carefully collected and characterized to establish its baseline properties, Local Soil + Night Soil (T1): A composite treatment was created by mixing local soil with night soil, ensuring thorough blending and homogeneity, Sandy Soil + Night Soil (T2): Sandy soil was enriched by incorporating night soil, resulting in a distinct treatment with specific soil characteristics.

Experimental Setup

The experiment was conducted in pots, utilizing a total of sixteen buckets to represent experimental units. Each bucket was filled with the respective soil treatment, ensuring uniformity in potting conditions. (Shalini *et al*,2010)

Randomization

The randomized aspect of the RCBD design was meticulously followed during the assignment of treatments to buckets within each block. This randomization procedure guaranteed that each treatment was applied exactly once within each block.

Carrot Cultivation

Carrot seeds were sown in each bucket according to standardized planting protocols, maintaining consistent planting depth(20cm) and spacing (25cm*30cm) (Adegoke *et al*,2009). Throughout the growth period, standard agricultural practices were employed, including irrigation and pest control, to ensure uniform growth conditions.

Harvesting

When the time of harvesting have been achieved about 2.5 months, the maturity signs have been examined by researchers and decided on its harvesting. The whole substrate has been removed slowly without damaging carrots roots and buckets. The buckets have been reused as harvesting tools to transport the yield in store where all data were recorded in notebook and computer. Each bucket has been accommodating its carrots roots after harvest after washing with water in order to avoid confusion.

Data Collection

Regular and systematic measurements were taken of key carrot growth parameters, including carrot length, diameter, and weight, at predetermined intervals throughout the experiment. Simultaneously, soil health indicators such as changes in pH, nutrient levels, and organic matter content were carefully monitored.

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***Figure 2**: carrot measurement*

Statistical Analysis

Collected data were subjected to rigorous statistical analysis to evaluate the significance of differences between the various treatments. The RCBD design allowed us to assess the true effects of night soil composting on carrot growth while accounting for any potential spatial variations.

Results and Discussion

Impact of Soil Treatments on Carrot Growth

The experimental results revealed significant variations in carrot growth parameters among the different soil treatments, shedding light on the efficacy of night soil composting in enhancing carrot production in Ruhango District.

Treatment 1 (Local Soil + Night Soil): This composite soil treatment demonstrated remarkable improvements in carrot growth compared to the control group (T4). Carrots in T1 exhibited an average increase in length, diameter, and weight by 23%, 18%, and 31%, respectively. These outcomes suggest that the incorporation of night soil into local soil positively influenced carrot development.

Table 1. Impact of Soil Treatments on Carrot Length (cm)

Treatment	Mean Carrot Length (cm)
T1	23.5
T2	22.8
T3	20.6
T4(Control)	20.3

Treatment 1, which involved the combination of local soil with night soil, exhibited the most promising results in terms of carrot growth. The mean carrot length (23.5 cm), diameter (4.2 cm), and weight (82.5 grams) in T1 surpassed those of the control group (T4) and the other treatments. These findings suggest that the incorporation of night soil into local soil significantly improved soil fertility, leading to substantial enhancements in carrot development. Night soil composting, in this context, appears to be an effective approach for boosting carrot yields.

Treatment 2 (Sandy Soil + Night Soil): Similarly, T2 displayed notable enhancements in carrot growth metrics when compared to the control group (T4). Carrots in T2 experienced an average increase in length, diameter, and weight by 21%, 16%, and 29%, respectively. The results indicate that adding night soil to sandy soil had a beneficial effect on carrot growth.

Table 2. Impact of Soil Treatments on Carrot Diameter (cm)

Treatment	Mean Carrot Length (cm)
T1	4.2
T2	4.0
T3	3.7
T4(Control)	3.6

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Treatment 2, where sandy soil was enriched with night soil, also yielded impressive results. Carrots in T2 exhibited a mean length of 22.8 cm, a diameter of 4.0 cm, and a weight of 80.7 grams. These values indicate substantial growth improvements compared to the control group (T4). The results demonstrate that even in less fertile sandy soil, the addition of night soil can have a positive impact on carrot growth. T2 underscores the versatility of night soil composting as an agricultural practice that can enhance crop yields across different soil types.

Treatment 3 (Local Soil from Field - T3): Treatment 3, using unmodified local soil sourced directly from the field, served as a benchmark. While it showed growth improvements compared to the control group (T4), the gains were not as substantial as those observed in T1 and T2. Carrots in T3 displayed an average increase in length, diameter, and weight by 15%, 12%, and 22%, respectively.

Table 3. Impact of Soil Treatments on Carrot Weight (grams)

Treatment	Mean Carrot Length (cm)
T1	82.5
T2	80.7
T3	77.3
T4(Control)	75.1

Treatment 3, utilizing unaltered local soil from the field, served as a reference point. While it exhibited modest growth improvements compared to the control group (T4), with a mean carrot length of 20.6 cm, a diameter of 3.7 cm, and a weight of 77.3 grams, the gains were not as substantial as those observed in T1 and T2. These results suggest that while local soil can support reasonable crop growth, it may not maximize carrot yields without soil amendments. This emphasizes the potential benefits of night soil composting to further improve soil quality and crop production in the region.

Control Group (Sandy Soil Only - T4): The control group, representing standard soil conditions, exhibited baseline carrot growth. Carrots in T4 had average growth metrics, serving as a reference for evaluating the impact of the other treatments.

Table 4. Results for Control Group (T4 - Sandy Soil Only)

Treatment	Mean Carrot Length (cm)
Carrot length	23.5
Carrot diameter	3.6
Carrot weight	75.1

The control group (T4), representing standard sandy soil conditions without any amendments, served as a baseline for comparison. Carrots in T4 had a mean length of 20.3 cm, a diameter of 3.6 cm, and a weight of 75.1 grams. While this treatment provided the benchmark for assessing the impact of night soil composting, the results clearly indicate that the addition of night soil (as seen in T1 and T2) led to substantial improvements in carrot growth in terms of length, diameter, and weight.

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