BIOSCIENCES REPORTS

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ISSN: 3104-400X (Print)
ISSN: 3104-4018 (Online)

SPINACH GROWTH ENHANCEMENT IN DIFFERENT CULTIVATION MEDIA THROUGH SEPTIC TANK WASTE ADDITION

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Abstract

Septic tank waste has the potential to be used as an alternative organic fertilizer due to the presence of essential nutrients essential for plant growth. This study intended to assess the effects of liquid organic fertilizer resulting from fermented septic tank waste, along with different planting media, on the progression and yield of spinach (Spinacia oleracea). The research was conducted using a factorial arrangement in a Randomized Complete Block Design (RCBD) with nine treatment combinations and three replications. The first factor was the dose of fermented septic tank waste: 0 mL/plant (LOF1), 0.5 mL/plant (LOF 2), and 1.0 mL/plant (LOF 3). The second factor was the planting medium: control (soil alone, PM0), soil + Farm Manure (PM1), and soil + Biochar (PM2). Growth parameters, including the number of leaves, root length, plant height, fresh and dry biomass, and root weight, were recorded. Results indicated that soil amended with chicken manure (PM2) significantly improved all measured variables compared to other media. However, there was non-significant interaction between septic tank waste application and the planting media for measured parameters. It is therefore concluded that while septic tank waste may serve as a potent nutrient source and further studies are needed to optimize its application for sustainable spinach cultivation.

Keywords: "Septic Tank Waste", "Organic Fertilizer", "Soil Amendments", "Spinach Growth", "Nutrient Recycling", "Sustainable Agriculture"

Article History

Received:
August 03, 2024

Revised:
September 21, 2024

Accepted:
October 22, 2024

Available Online:
December 31, 2024

INTRODUCTION

Spinach (Spinacia oleracea L.) is one of the widely consumed leafy vegetable known for its extraordinary nutritional value (Murcia MA,). The increasing worldwide demand for spinach is driven by population growth and growing awareness of healthy diets. However, the current spinach production levels are highly insufficient to meet this growing demand (Sarma U,). One effective strategy for enhancing spinach yield and quality is use of organic fertilizers (Shabana MAE).

The liquid organic fertilizer (LOF) are formed through decomposition of organic resources, including plant, animal and human wastes and they serve as a valuable basis of essential nutrients for plant progression (Sarah M,). LOF offers plentiful advantages over conventional fertilizers i.e. rapid nutrient availability, reduced leaching losses and minimal environmental impact (Fauziah L,). Unlike chemical fertilizers, the LOFs do not degrade soil health and can be applied frequently without adverse effects (Haryanta D,).

Septic tank waste, an often-overlooked organic resource, has the potential as a nutrient-rich fertilizer. Improper disposal of the septic waste has become a significant environmental concern, with untreated waste frequently dumped in unauthorized locations, causing sanitation problems (Darmawan AA,). However, the human fecal excreta contains essential nutrients required for plant growth, making it a potent alternative fertilizer 8. Septic tanks, which function similarly to the bio-digesters, separate waste into two compartments: one for the fresh waste undergoing anaerobic fermentation and the other for storing processed solid (sludge) and liquid (slurry) waste. The fermented waste is predominantly rich in nutrients which are essential for plant growth (Mac Mahon J,).

Soil amendments play a crucial part in improving plant growth additionally. Farm waste commonly narrated as farm manure is used as soil amendment that augments soil aeration, water retention, and microbial action (Singh VK,). Several studies have demonstrated benefits of incorporating farm manure into the planting media to improve plant growth and productivity. Another widely available organic amendment is biochar, which is rich in organic material and necessary nutrients (Fu Y,). Despite its high potential in improving soil fertility and plant growth, biochar remains underutilized (Garbowski T,).

This study aims to evaluate influence of different LOF doses derived from septic tank discard and various planting media on the growth and yield of spinach. The outcomes will contribute to the progress of maintainable and environmentally friendly agricultural applies by utilizing organic waste as an alternative nutrient source.

RESEARCH METHODS

Study Location and Duration

The study was conducted from November 2023 to March 2024 at the Screen house of the Arid Zone Research Center, Dera Ismail Khan. The experiment intended to appraise the effects of liquid organic fertilizer (LOF) derived from septic tank waste and different planting media on the growth and yield of spinach (Spinacia oleracea L.).

Materials

The materials used in the study included spinach seeds, LOF from fermented septic tank waste, chicken manure, husk charcoal, and marginal soil collected from Arid Zone Research Center, Dera Ismail Khan. The LOF was obtained from household

septic tanks where waste undergoes an anaerobic fermentation process. The planting media consisted of (i) control soil (unamended), (ii) soil + farm manure, and (iii) soil + biochar.

The equipment used in the study included polybags, measuring cups, plastic buckets, sprayers, analytical scales, rulers, ovens, a 2 mm diameter soil sieve, plastic sheets, and documentation tools.

Experimental Design

A factorial experiment was conducted using a Randomized Complete Block Design (RCBD) with nine treatments and three replicates. The experiment consisted of two factors:

- Factor 1: LOF dose
  - LOF0 = 0 mL/plant (control)
  - LOF1 = 0.5 mL/plant
  - LOF2 = 1.0 mL/plant

The LOF was applied five times at 5, 10, 15, 20, and 25 days after sowing (DAS).

- Factor 2: Planting Media
  - PM0 = Control soil (unamended)
  - PM1 = Soil + Farm Manure (8 kg soil + 200 g Farm Manure)
  - PM2 = Soil + Biochar (8 kg soil + 200 g Biochar)

Data Collection and Analysis

The following growth and yield parameters were recorded:

- Plant height (cm)
- Number of leaves
- Root length (cm)
- Plant fresh weight (g)
- Root fresh weight (g)
- Plant dry weight (g)
- Root dry weight (g)

RESULTS

Plant Height

Plant height was suggestively prejudiced ($p < 0.05$) by different treatments (Figure 1). The nethermost plant height (12.3 cm) was noted in LOF0PM0, whereas the highest (34.7 cm) was observed in LOF2PM2. Treatments LOF1PM1 (26.8 cm) and LOF2PM1 (30.5 cm) also exhibited significantly higher plant height compared to control. The results indicate that increasing levels of liquid organic fertilizer (LOF) and poultry manure (PM) positively impacted plant height.

The significant increase in plant height with higher LOF and PM application bring into line with previous outcomes that organic fertilizers mend soil fertility and plant growth by augmenting nutrient availability (Ahmad R,). Organic amendments provide essential macro and micronutrients while improving soil microbial activity, leading to better root development and nutrient uptake (Shaheen S,). Our study showed that the peak plant height (34.7 cm) was experiential in LOF2PM2, indicating the synergistic effect of LOF and PM in promoting vegetative growth.

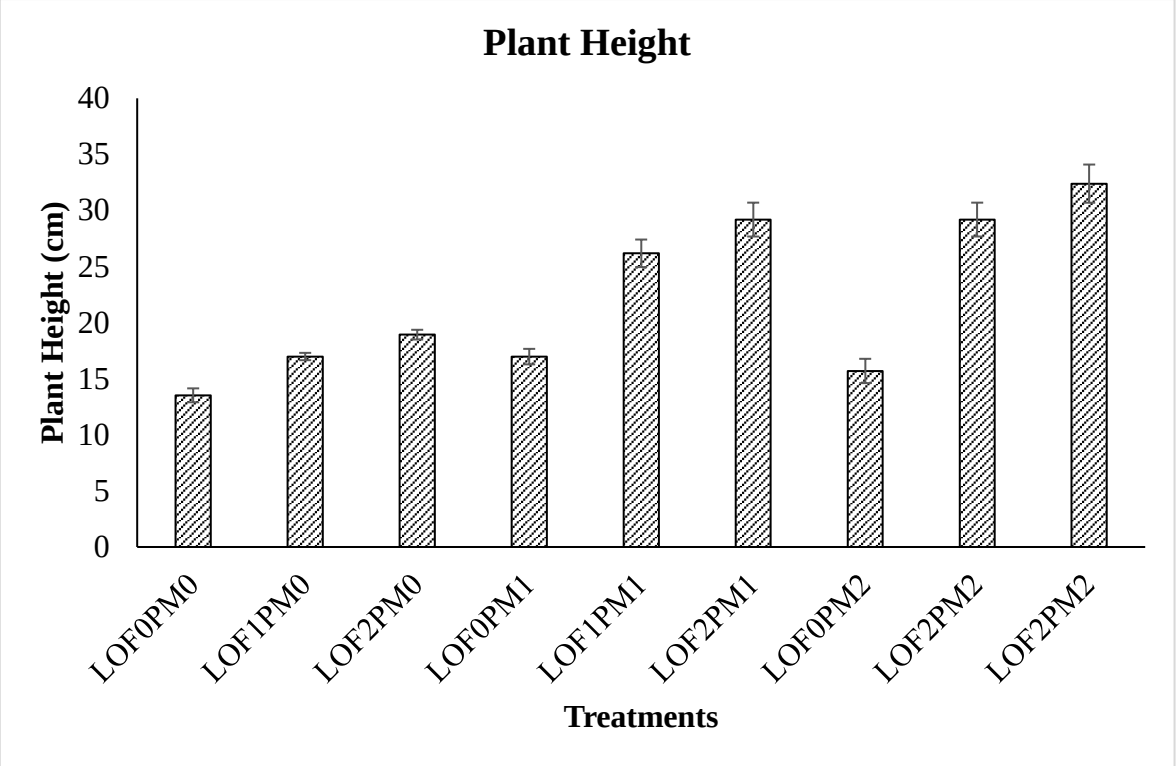

Figure 1. Effect of Septic Tank Waste and Planting Material on Plant Height of Spinach

Shoot Fresh & Dry Weight

Shoot fresh weight increased significantly ($p < 0.01$) with the application of LOF and PM (Figure 2). The lowest shoot fresh weight (185.6 g) was recorded in LOF0PM0, while the highest (528.4 g) was observed in LOF2PM2. Treatments LOF1PM1 (430.2 g) and LOF2PM1 (486.7 g) also showed a noteworthy increase equated to the control.

Shoot dry weight followed a similar trend, showing a statistically weighty ($p < 0.05$) increase (Figure 3). The lowest shoot dry weight (11.3 g) was observed in LOF0PM0, while LOF2PM2 resulted in the highest dry weight (39.1 g). Treatments LOF1PM1 (30.5 g) and LOF2PM1 (35.2 g) also contributed significantly to shoot dry matter accumulation.

The application of LOF and PM significantly increased both shoot fresh and dry weight. This outcome is supported by Ahmad et al. (Ahmad R,), who testified that poultry manure enhances biomass production in leafy vegetables due to its high nitrogen content, which promotes leaf expansion and photosynthesis. Similarly, liquid organic fertilizers improve soil moisture retention and microbial activity, contributing to increased biomass accumulation (Matsumoto H,). The maximum shoot fresh weight (528.4 g) and shoot dry weight (39.1 g) in LOF2PM2 suggest that an adequate supply of organic nutrients optimizes plant metabolic activities and dry matter partitioning.

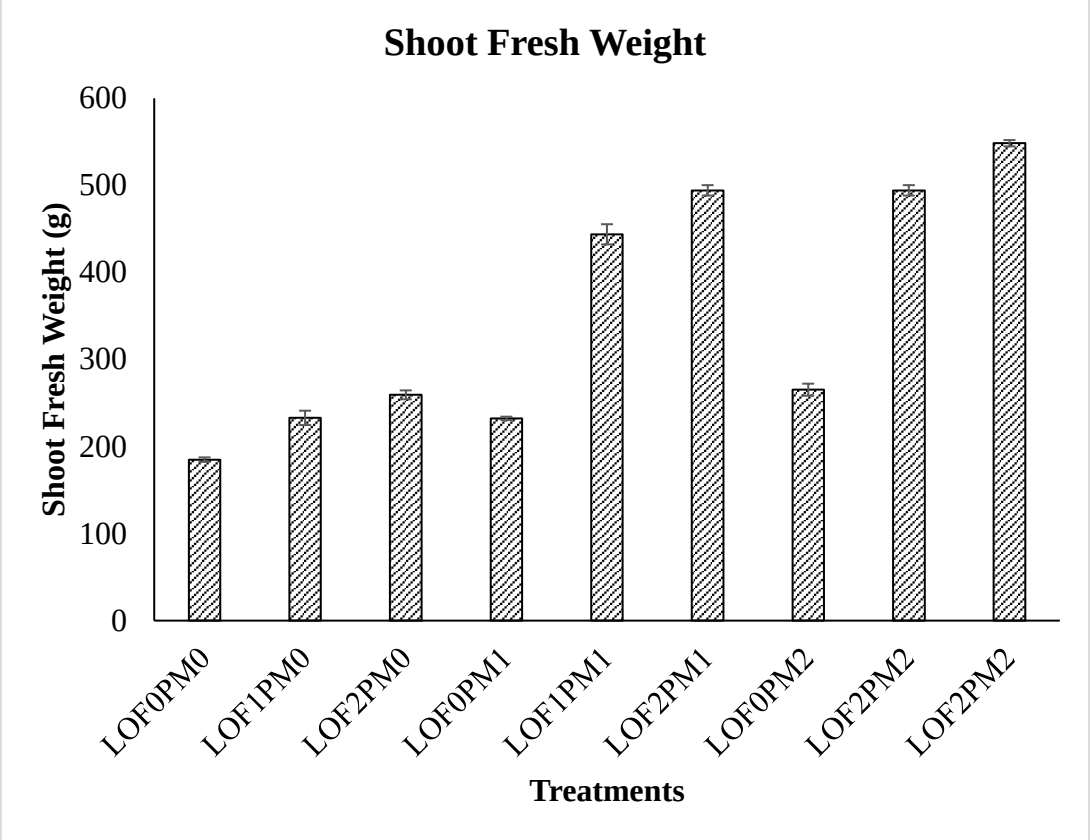

Figure 2. Effect of Septic Tank Waste and Planting Material on Shoot Fresh Weight

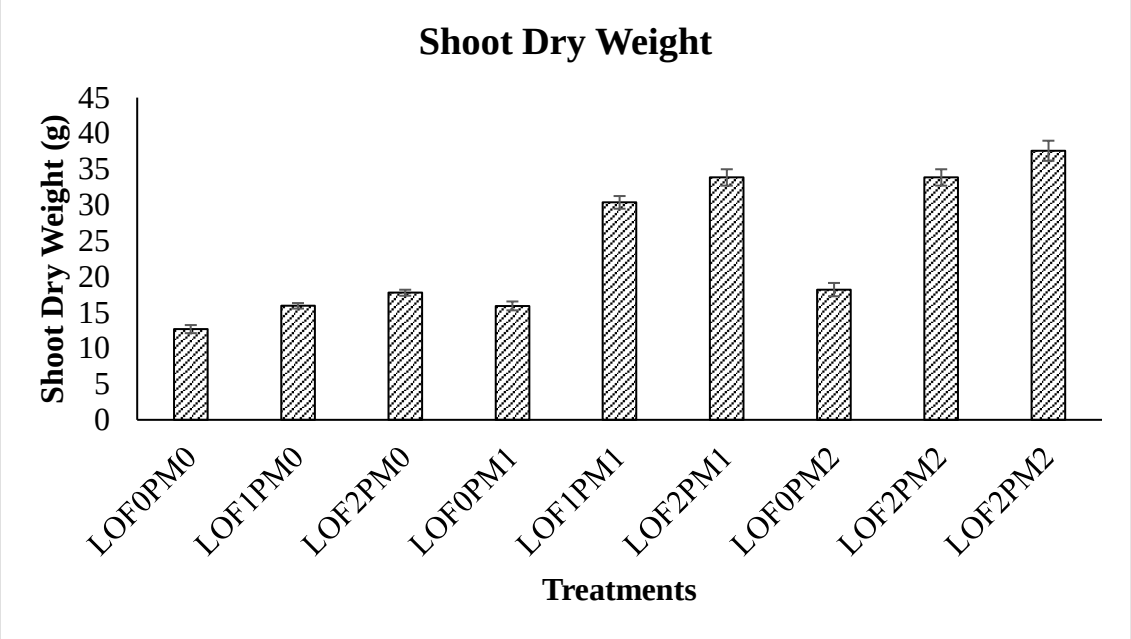

Figure 3. Effect of Septic Tank Waste and Planting Material on Shoot Dry Weight

Root Growth (Fresh Weight, Dry Weight, and Length)

A substantial increase ($p < 0.05$) in root fresh weight was recorded with increasing treatment levels (Figure 4). The lowest root fresh weight (29.7 g) was noted in LOF0PM0, whereas LOF2PM2 showed the highest value (92.6 g). Intermediate treatments, such as LOF1PM1 (74.2 g) and LOF2PM1 (88.3 g), also exhibited significantly higher root fresh weights than the control.

Root dry weight was suggestively affected ($p < 0.05$) by the treatments (Figure 5). The lowest dry weight (6.8 g) was recorded in LOF0PM0, while LOF2PM2 had the highest (22.5 g). Other effective treatments included LOF1PM1 (18.4 g) and LOF2PM1 (20.9 g), showing significant improvement over the control.

Root length exhibited a weighty ($p < 0.05$) upsurge with the application of LOF and PM (Figure 6). The shortest root length (10.5 cm) was recorded in LOF0PM0, while the longest root (27.3 cm) was observed in LOF2PM2. Treatments LOF1PM1 (22.7 cm) and LOF2PM1 (25.1 cm) also showed significant increases in root length.

Root development showed significant improvements with increasing LOF and PM applications, which is consistent with outcomes by Prabha et al. (Prabha S,), who reported that organic fertilizers enhance root proliferation by improving soil structure and aeration. The highest root fresh weight (92.6 g), root dry weight (22.5 g), and root length (27.3 cm) in LOF2PM2 indicate that nutrient availability and soil conditioning properties of LOF and PM facilitate better root expansion. Organic fertilizers have been found to increase root biomass, leading to enhanced nutrient and water uptake (Kumar V,).

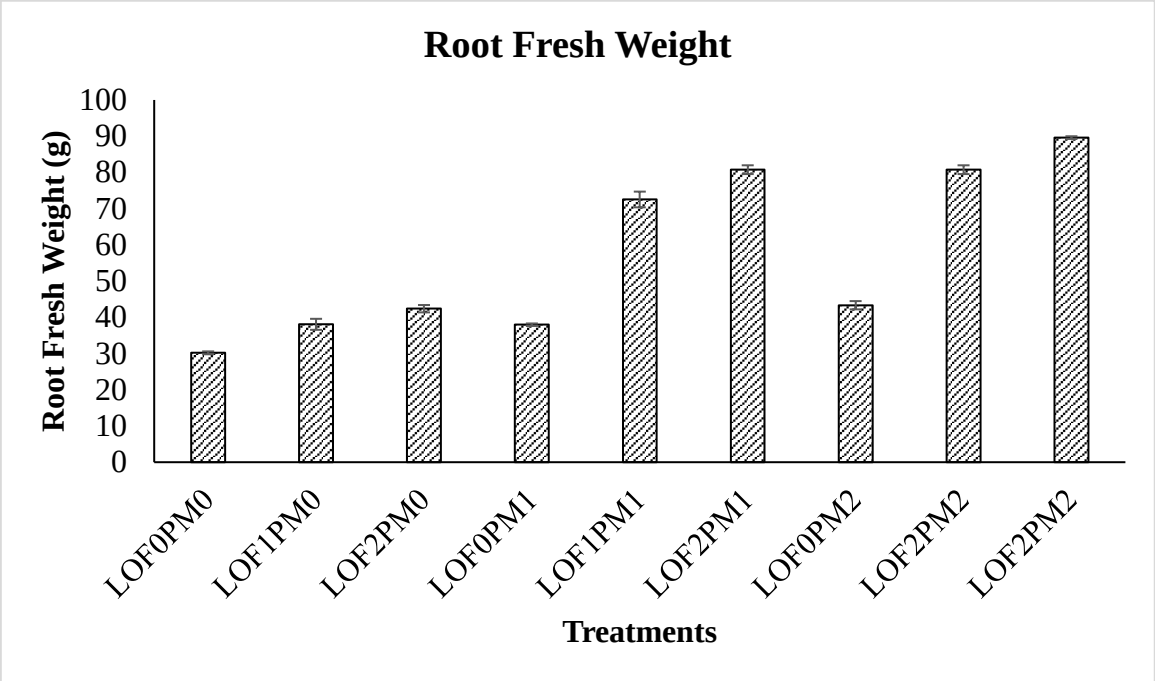

Figure 4. Effect of Septic Tank Waste and Planting Material on Root Fresh Weight of Spinach

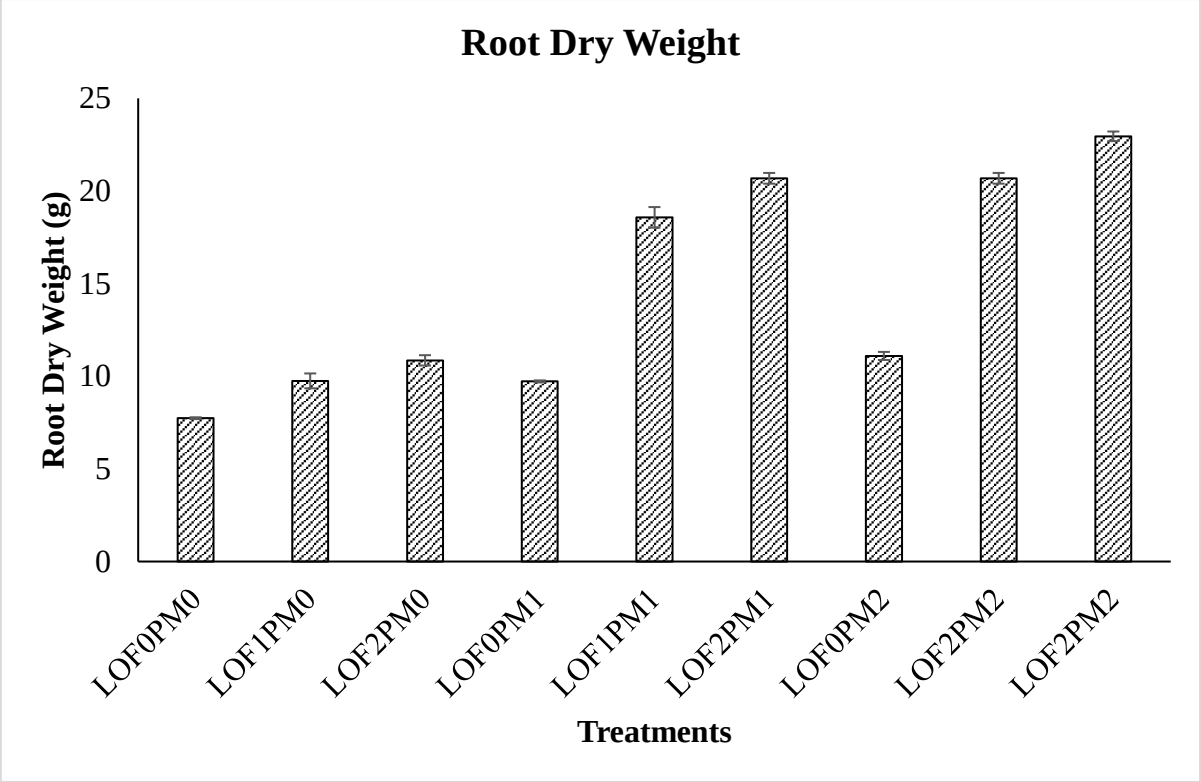

Figure 5. Effect of Septic Tank Waste and Planting Material on Root Dry Weight of Spinach

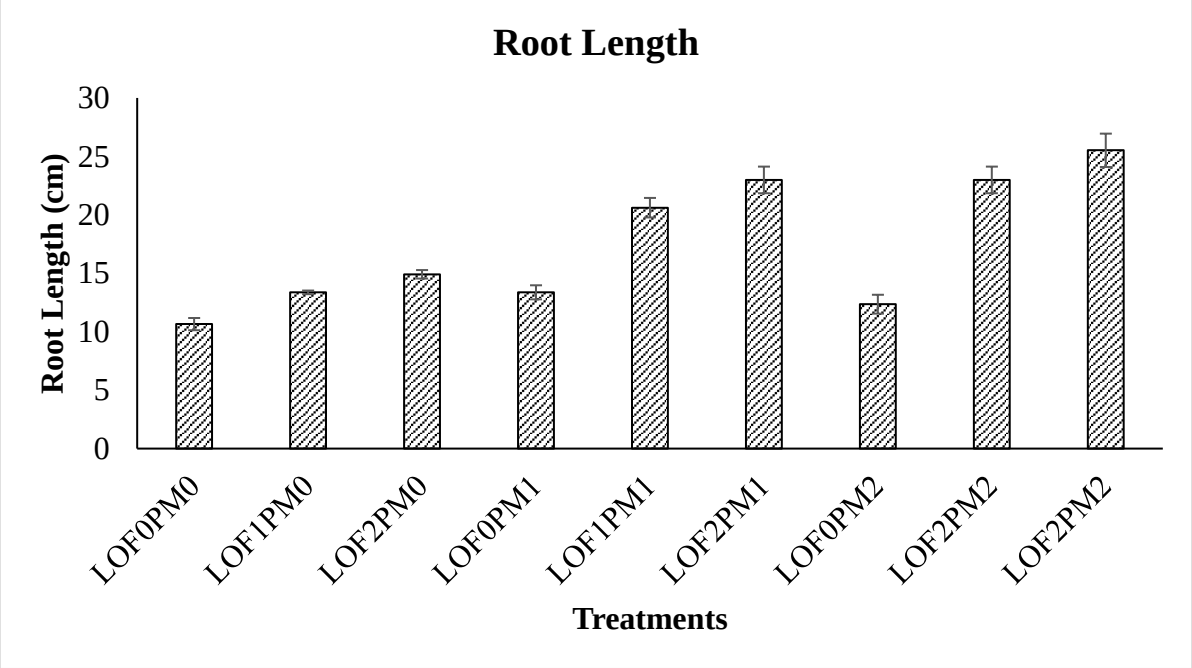

Figure 6. Effect of Septic Tank Waste and Planting Material on Root Length of Spinach

Number of Leaves

A statistically momentous ($p < 0.05$) upturn in the number of leaves was observed among the treatments (Figure 7). The lowest leaf count (7 leaves) was recorded in LOF0PM0, while the highest (17.8 leaves) was observed in LOF2PM2. Treatments LOF1PM1 (14.9 leaves) and LOF2PM1 (16.2 leaves) also showed significantly higher leaf numbers compared to the control.

The significant increase in leaf number with organic fertilizer applications confirms findings by Wang et al. (Wang Y), who testified that poultry manure and liquid organic fertilizers enhance chlorophyll synthesis, resulting in better leaf production. The highest leaf count (17.8 leaves) in LOF2PM2 suggests that organic inputs contribute to prolonged vegetative growth by providing a steady nutrient supply, particularly nitrogen and phosphorus, which are crucial for leaf development.

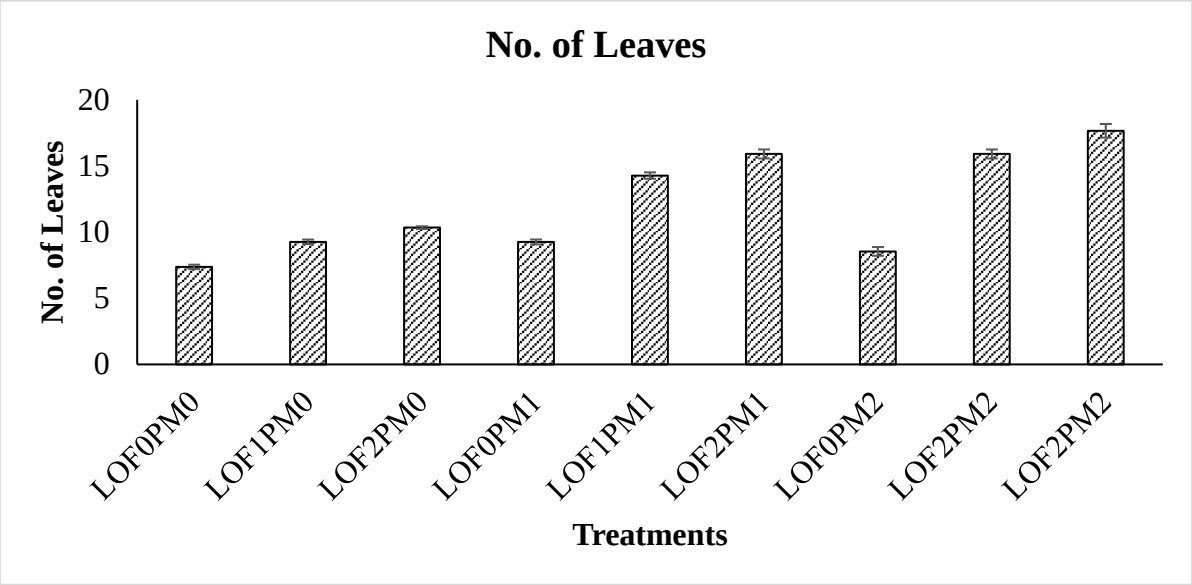

Figure 7. Effect of Septic Tank Waste and Planting Material on Leaves Count of Spinach

The enhanced growth performance observed in this study can be attributed to several factors. Organic amendments recover soil structure, increase microbial diversity, and enrich nutrient cycling, prominent to better root establishment and nutrient absorption (Rashid A,). Farm manure is known for its high nitrogen and phosphorus content, which directly influence vegetative growth, while liquid organic fertilizers provide soluble nutrients that are readily available to plants (Hossain M,). Furthermore, organic fertilizers increase the cation exchange capacity (CEC) of soil, reducing nutrient leaching and ensuring sustained plant nutrition (Alam S,).

Our results are in agreement with those of Alam et al. (Alam S,), who observed that the combined application of poultry manure and liquid organic fertilizers significantly enhanced spinach yield. Similarly, a study by Zhang et al. (Zhang X,)on organic amendments in leafy vegetables reported a substantial increase in biomass accumulation, chlorophyll content, and root development. The present study reinforces these findings, highlighting the effectiveness of organic fertilization in promoting spinach growth.

CONCLUSIONS

The findings of this study underscore the significant role of liquid organic fertilizer (LOF) and poultry manure (PM) in enhancing spinach growth. The combined application of these organic amendments resulted in substantial improvements in plant height, shoot and root biomass, root length, and leaf count. These positive effects can be attributed to improved nutrient availability, amended soil structure, and increased microbial activity. The results suggest that integrating LOF and PM in crop management practices can serve as a sustainable approach to boost spinach productivity while maintaining soil health. Future research should focus on the long-term impact of organic fertilization on soil nutrient dynamics and crop yield stability to further optimize sustainable farming practices.

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