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Utilization of Kitchen Waste for Enhanced Potted Vegetable Production

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Abstract

The growing concern over food waste and chemical fertilizer dependency has increased interest in sustainable alternatives for home gardening. This study evaluates the potential of processed kitchen waste as an organic fertilizer for improving the growth and yield of potted fenugreek (Trigonella foenum-graecum). The experiment was conducted using a Completely Randomized Design (CRD) with sixteen treatments and three replications, involving five organic waste sources-used tea, potato peels, onion scales, garlic scales, and eggshells-each applied at three dosage levels (0.025g, 0.25g, 2.5g). All waste materials were cleaned, dried, and ground into powder before application. Fenugreek was grown in silt-filled pots, and data on plant height, number of leaves, fresh and dry biomass, and dry matter content were recorded throughout the growth cycle. The results revealed that garlic scales at 0.25g significantly enhanced fresh biomass (24.2 g), while used tea and onion scales improved early plant height and leaf number due to their readily available nutrients and bioactive compounds. Eggshells and potato peels also contributed to plant growth, but had slower nutrient release. The control treatment, without any organic amendment, consistently showed the lowest performance across parameters. Overall, the findings indicate that kitchen waste, especially garlic scales and used tea, can serve as effective, low-cost organic amendments in small-scale vegetable cultivation. The study supports the integration of kitchen waste recycling into urban and home gardening practices as a sustainable approach to reduce waste and enhance food production.

1. Introduction

Fertilizers are defined as any natural or inorganic substance of pure or artificial origin that is inserted into the land to provide nutrients to the crops that are important for the development of the plants. Vegetables include a great quantity of antioxidants that are helpful to our well-being in many ways (Agbenin *et al.,* 2004). Natural fertilizers consist of ingredients consists of mineral sources, all animal waste, and plant-based fertilizers, which are of animal and plant sources respectively. Inorganic fertilizers are typically entirely produced, as in the case of sulphate of ammonia, or they may be treated from an extracted or dug mineral. Fertilizers are normally delivered in differing amounts. Excellent potency is essential to efficient plant growth, and the usage of fertilizers and composts is an important aspect of interest. The preservation of sufficient concentrations of nutrients in the land is vital for the healthful growth of plants. Analysis of the soil can help to avoid overuse by determining current soil nutrient concentrations (Faria *et al.,* 2006). More than 26 million tons of food waste were generated in 2001, accounting for about 16% of the municipal solid waste stream in the United States (Miller, 2004). Consequently, composting has become an attractive means for deterring food waste from landfills and reducing waste management

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costs. Onion is a multi-use vegetable that is consumed fresh as salad as well as in the form of several processed products (C.M. Manohar *et al.,* 2017). Regular consumption of onions has been shown to reduce the risk of cancer, cataract and DNA damage, vascular and heart diseases (E.T. Arung *et al.,* 2011; L. Jimenez *et al.,* 2011; Y. Hamauzu *et al.,* 2011). The presence of onions and garlic in the pan-fried meat has been shown to reduce the formation of carcinogenic heterocyclic amines and azaarenes in the cooked meat samples (B. Janoszka, 20101.The present study deals with the utilization of vegetable peels and kitchen waste for the effective growth of plants and higher yield. Vegetable peels such as potato, scales of garlic, onion, raw eggs and used tea powder were used.

Comprehensive research was conducted at UAF Sub Campus Burewala, considering the importance of the utilization of vegetable peel powder as a natural growth enhancer. An experiment was conducted to assess the impact of different sources of kitchen waste on the growth of pot-grown fenugreek. The objectives of the experiment were.

- To find out the best source as organic fertilizer among used tea, potato peels, garlic scales, onion scales and eggshells.
- To find out the optimum dose of the said fertilizers.

2. Materials and Methods

2.1. Materials

Healthy seeds of fenugreek (*Trigonella foenum-graecum*) were procured from the local market of Burewala. A total of seventeen clay pots, each with a diameter of 10 inches, were obtained from the nursery of the University of Agriculture Faisalabad, Sub Campus Burewala. Silt was used as the growing medium, with each pot filled with 1.5 kg of silt. Vegetable peels were separately collected from kitchen waste to be used in the study. Essential laboratory instruments, including a weighing balance, hot air oven, and grinding mill, were acquired from the laboratories of UAF Sub Campus Burewala for conducting experimental analyses.

2.2. Methods

A pot experiment was carried out at the open field farm of UAF Sub-Campus Burewala-Vehari, Pakistan, located in the Eastern Province of Pakistan, which falls under the temperate zone. Experiment was carried out in a Completely Randomized Design (CRD) with sixteen treatments, which were replicated thrice. Vegetable peels of onion scales (OS), garlic scales (GS), potato peels (PP), used tea (UT) and eggshells (ES) were collected separately from kitchen waste. Collected peels were washed thoroughly with tap water to remove the unwanted material. The washed peels were cut into small pieces (1-5cm) and air dried for 20 days. Then, the dried peels were placed in a hot air oven at 80°C for further drying. After drying, the weight of the peels was recorded.

To make particles of suitable size Grinding Mill was used with a mesh size of 50. Weight of each material is carefully recorded after each stage mentioned in Table 1. Before pot filling, silt was added about 1/3 of each pot volume. A Pebble was also placed at the bottom of each pot for proper drainage and to prevent water stagnation in pots. Three different doses of each source of kitchen waste were weighed (0.025g, 0.25g, 2.5g) using the weighing balance. Fenugreek seeds were sown on 8th January 2021. Initially, three lines were drawn in each pot using a stick (each line will be considered as a single replication). Irrigation water was applied immediately after sowing with help of hand shovel. Irrigation was applied on daily basis with the help of a hand shower. No extra fertilizer was added to the pots. To protect the plants from severe frost, a low-level tunnel was constructed over the pots (with the help of sticks and polythene sheets). The pots were inspected regularly. Hand weeding was practiced where needed.

Table 1. Weight loss of waste material during preparation

Material used	Before Drying	After Drying	Final weight after crushing
Garlic scales	17.47g	10.23g	9.84g
Onion scales	34.43 g	21.15g	10.78g
Egg shell	90.80g	84.62g	83.00g
Potato peel	45.47g	37.00g	34.20g
Tea (used)	105.9g	26.30g	25.70g

2.3.1 Data collection

2.3.1.1. Plant height and rate of height increase:

Plant height was recorded at four distinct growth stages during the cropping season, specifically on January 28, February 10, February 22, and March 13, 2021. At each observation, two plants were randomly selected from each row within a pot, resulting in a total of six plants per pot. A plastic ruler was used for measuring plant height from the base to the tip of the longest leaf. The mean plant height was calculated and expressed in centimetres, and designated as PH_1, PH_2, PH_3, and PH_4 corresponding to each observation date. To assess vegetative growth dynamics, the rate of plant height increase (RPHI) between two consecutive observation dates was calculated using the following formula:

$$\text{RPHI}\ \left({}^{cm}/_{day}\right) = \frac{PH_f - PH_i}{\text{No. of days between } PH_i \text{ and } PH_f}$$

Where:

PH_i = Initial plant height (cm)
PH_f = Final plant height (cm)

This approach allowed for the quantification of growth rate trends over time under different treatment conditions.

2.3.1.2. No. of leaves and rate of leaf increase

Number of leaves was also counted four times using similar methods as described for plant height determination. Number of leaves (NOL) was counted by non-destructive method. Following formula was used to calculate growth rate:

$$\text{NOL}\ \left({}^{cm}/_{day}\right) = \frac{NOL_f - NOL_i}{\text{No. of days between } NOL_i \text{ and } NOL_f}$$

Where:

NOL_i = Initial number of leaves
NOL_f = Final number of leaves

2.3.1.3. Fresh weight

Three pickings of fenugreek were taken on 3 March 16th March and 29th March 2022). Sharp knife was used to cut the leaves leaving 2cm of stem from the base. Harvested leaves were weighed on digital weighing balance and expressed in grams (g).

2.3.1.4. Dry weight and Dry Matter Contents (%)

Dry weight and Dry Matter Contents (%) of fenugreek leaves were calculated by the oven drying method as suggested by AOAC (1995).

2.3.2 Statistical analysis

All treatments were laid out in a completely randomized design with three replications. Least significant difference (LSD) was used to find the differences between mean values at 5% level of significance.

3. Results

Data on plant height showed significant results under different growing media (Table 2). At the start rate of plant height was better in used tea (UT) garlic scales (GS) and onion scales. Used tea is readily available and has nitrogen and caffeine. Onion scales and garlic scales have micronutrient and antimicrobial compounds that suppress harmful pathogens earlier and give the plant a healthier start (Sharma *et al.,* 2020). Some treatments (onion scale, potato peels, eggshells) show better results later due to the decompose slowly and provide a more balanced nutrient profile.

Onion Scales and garlic are high in sulfur and micronutrients, so rapid mineral release (Table 3). Calcium from eggshells boosts early cell wall formation (Oliveira et al.2015) Used Tea delivers easily available nutrients (like nitrogen) and growth stimulants (like caffeine and tannins).

Garlic Scales 2.5 g showed a spike in RNL2, suggesting strong mid-growth benefits due to accumulated nutrients and bioactivity. Onion Scales 2.5 g have a very high RNL3 (1.8), showing excellent long-term leaf growth. This effect is due to the gradual decomposition of organic matter. Potato peels may release nutrients more slowly or inefficiently for leaf production. The control group, expectedly, shows relatively lower performance, lacking nutrient supplementation.

Highest fresh weight garlic Scales 0.25 g, dramatically boosting fresh biomass yield (Table 4). This could be due to Antimicrobial and growth-promoting compounds reducing plant stress and enhancing nutrient uptake. High dry weight means better structural growth. Garlic and potato peels provided both nutrients and resistance to microbial attack (Rahman, 2007). Dry weight increase confirms sustainable biomass, not just water retention. DMC reflects nutrient-dense, less watery tissue-important for quality. Used tea provides polyphenols, caffeine, and nitrogen, stimulating secondary metabolism and increasing solids. Control plants, lacking organic treatments, had the lowest biomass and quality. Confirms the importance of organic soil amendments in plant performance.

Table 2. Impact of different treatments on the rate of plant height increase in fenugreek

Treatments	RPH1	RPH2	RPH3
T_1 (UT 0.025g/12-inch silt filled pot)	0.31b	0.08de	0.12g
T_2 (UT 0.25g/12-inch silt filled pot)	0.29bc	0.11cde	0.14fg
T_3 (UT 2.5g/12-inch silt filled pot)	0.3bc	0.21a	0.13g
T_4 (PP 0.025g/12-inch silt filled pot)	0.16hi	0.22a	0.18de
T_5 (PP 0.25g/12-inch silt filled pot)	0.16ghi	0.18ab	0.07h
T_6 (PP 2.5g/12-inch silt filled pot)	0.13i	0.17abc	0.35a
T_7 (GS 0.025g/12-inch silt filled pot)	0.2fg	0.1cde	0.13g
T_8 (GS 0.25g/12-inch silt filled pot)	0.4a	0.23a	0.26c
T_9 (GS 2.5g/12-inch silt filled pot)	0.2f	0.1de	0.21d
T_{10} (OS 0.025g/12-inch silt filled pot)	0.32b	0.05e	0.07h
T_{11} (OS 0.25g/12-inch silt filled pot)	0.24de	0.19ab	0.29b
T_{12} (OS 2.5g/12-inch silt filled pot)	0.28cd	0.12a	0.38a
T_{13} (ES 0.025/12-inch silt filled pot)	0.2fgh	0.23a	0.21d
T_{14} (ES 0.25g/12-inch silt filled pot)	0.25de	0.08de	0.08h
T_{15} (ES 2.5g/12-inch silt filled pot)	0.2fg	0.08de	0.17ef
T_{16} Control (12-inch silt filled pot)	0.21ef	0.24a	0.21d

Where UT=used tea, PP=Potato peels, GS=Garlic scales, OS=Onion Scales, ES=Egg shells

Table 3. Impact of different treatments on the rate of number of leaves in fenugreek

Treatments	RNL1	RNL2	RNL3
T_1 (UT 0.025g/12-inch silt filled pot)	0.29abc	0.46de	0.75cdef
T_2 (UT 0.25g/12-inch silt filled pot)	0.26abcd	0.5cde	0.95bc
T_3 (UT 2.5g/12-inch silt filled pot)	0.14d	0.85abcd	0.93bcd
T_4 (PP 0.025g/12-inch silt filled pot)	0.23bcd	0.4de	0.2gh
T_5 (PP 0.25g/12-inch silt filled pot)	0.23bcd	0.48de	0.3gh
T_6 (PP 2.5g/12-inch silt filled pot)	0.3ab	0.5cde	0.8cde
T_7 (GS 0.025g/12-inch silt filled pot)	0.25abcd	1a	0.55defg
T_8 (GS 0.25g/12-inch silt filled pot)	0.32ab	0.98ab	0.7cdef
T_9 (GS 2.5g/12-inch silt filled pot)	0.29abc	1.15a	0.4fgh
T_{10} (OS 0.025g/12-inch silt filled pot)	0.37a	0.53bcde	0.21gh
T_{11} (OS 0.25g/12-inch silt filled pot)	0.38a	0.95abc	0.3gh
T_{12} (OS 2.5g/12-inch silt filled pot)	0.35ab	0.8abcde	1.81a
T_{13} (ES 0.025/12-inch silt filled pot)	0.37a	0.35e	1.3b
T_{14} (ES 0.25g/12-inch silt filled pot)	0.37a	0.51cde	0.56cdefg
T_{15} (ES 2.5g/12-inch silt filled pot)	0.29abc	0.83abcd	0.13h
T_{16} Control (12-inch silt filled pot)	0.15cd	0.82abcde	0.4efgh

Where UT=used tea, PP=Potato peels, GS=Garlic scales, OS=Onion Scales, ES=Egg shells

Table 4. Impact of different treatments on yield attributes of fenugreek

Treatments	Fresh weight (g)	Dry weight (g)	DMC (%)
T_1 (UT 0.025g/12-inch silt filled pot)	10cd	1.1efg	11c
T_2 (UT 0.25g/12-inch silt filled pot)	9.8cd	1.07fgh	10.9cde
T_3 (UT 2.5g/12-inch silt filled pot)	7f	0.89hi	12.7b
T_4 (PP 0.025g/12-inch silt filled pot)	13.2b	1.4bcd	10.6fg
T_5 (PP 0.25g/12-inch silt filled pot)	5.12g	0.55j	10.7def
T_6 (PP 2.5g/12-inch silt filled pot)	13.6b	1.34bcd	10.4g
T_7 (GS 0.025g/12-inch silt filled pot)	24.2a	2.3a	9.9h
T_8 (GS 0.25g/12-inch silt filled pot)	13.4b	1.34bcd	16.1a
T_9 (GS 2.5g/12-inch silt filled pot)	13b	1.43bc	9.93h
T_{10} (OS 0.025g/12-inch silt filled pot)	9.38de	1.03gh	11cd
T_{11} (OS 0.25g/12-inch silt filled pot)	13.4b	1.27cde	10.9cd
T_{12} (OS 2.5g/12-inch silt filled pot)	13.8b	1.48b	9.5i
T_{13} (ES 0.025/12-inch silt filled pot)	12.9b	1.34bcd	10.4g
T_{14} (ES 0.25g/12-inch silt filled pot)	11c	1.21defg	11cd
T_{15} (ES 2.5g/12-inch silt filled pot)	7.54f	0.72ij	9.6i
T_{16} Control (12-inch silt filled pot)	7.94ef	1.26cdef	9.5i

Where UT=used tea, PP=Potato peels, GS=Garlic scales, OS=Onion Scales, ES=Egg shells

4. Conclusion

This study demonstrates the potential of kitchen waste as a valuable resource for improving fenugreek production in pots. Incorporation of specific kitchen waste like garlic scales, onion scales, and egg shells is highly recommended for an early-stage boost in plant growth as well as late-stage enhanced vegetable production under pots.

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7. Conflict of Interest

The authors declare no conflict of interest.

8. Authors' Contribution

Nimra Khaliq conducted experimental research and data analysis. Salman Zahoor was responsible for manuscript formatting and literature review. Bisma Shahbaz contributed to data collection and assisted in the review of relevant literature. Rana Binyamin critically reviewed the paper.

9. SDGs Addressed

This study addresses SDG 2: Zero Hunger by enhancing potted vegetable production through sustainable nutrient sources, SDG 12: Responsible Consumption and Production by recycling kitchen waste into organic fertilizer, and SDG 13: Climate Action by reducing reliance on synthetic fertilizers and minimizing environmental impact.

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