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RESEARCH ARTICLE

Assessing the Potential of Cattle Manure and Extracts of Tea Waste and Eggshell as Soil Application on Growth and Yield of Okra (*Abelmoschus esculentus* L.)

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ABSTRACT

Utilizing domestic wastes as organic fertilizer in agriculture leads to reduce the quantity of global waste and provide organic substitute for chemical fertilizers. This experiment was carried out to assess the potential of cattle manure and household waste (tea waste and eggshell) extracts on the growth and yield parameters of okra (Abelmoschus esculentus L.). The experimental design was a completely randomized design with eight treatments which were applications of no any fertilizers as a control (T1), chemical fertilizers (T2), cattle manure (CM) alone (T3), CM + tea waste (T4), CM + eggshell (T5), CM + eggshell treated with vinegar (T6), CM + tea waste + eggshell (T7) and CM + tea waste + eggshell treated with vinegar (T8). In this experiment, cattle manure (10 t/ha) was applied to T3-T8 treatments as basal soil application. Chemical fertilizers and cattle manure were applied based on the polybag size (0.15 m^2). The diluted extracts of tea waste (100 mL per plant) and eggshell (50 mL per plant) were added to the soil as top dressing. The results indicated that soil application of cattle manure with tea waste and eggshell extracts had significant ($p<0.05$) effects on number of pods per plant, weight of pods per plant, root length, weight of crop residue and marketable pod yield than T3 treatment. Further, this study revealed that T8 and T7 treatments increased the marketable pod yield by 23.4% and 15.1% respectively, compared to T2 treatment (chemical fertilizer) but statistically similar value was noted between them. Based on the results obtained in this study, combined use of cattle manure along with tea waste and eggshell treated vinegar extract as organic liquid fertilizer can be used in okra cultivation for enhancing crop yield in sandy regosol soil conditions. Suggestion for future study is to assess the impact of the specified treatment on yield and quality of okra under different soil conditions.

***Keywords**: Household waste, Organic fertilizer, Sandy regosol soil, Vinegar*

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is one of the widely cultivated vegetable crops in different countries, particulary in the Asian Region. The immature green pods of okra are generally consumed as vegetables. The application of fertilizers is needed to increase the soil nutrients and crop yield. Okra requires nutrients such as nitrogen, phosphorus, potassium, calcium, sodium, and sulphur for increasing crop production. Chemical fertilizers provide the essential nutrients quickly while organic manures supply both macro and micronutrients for crop growth and its subsequent development (Nemitha and Seran, 2024). The application of organic fertilizer is a possible way to mitigate the soil degradation resulted by excess use

of chemical fertilizers which can have impact on the soil bacterial diversity (Zhang *et al.*, 2020). Organic manures are usually low-cost and environmentally friendly (Samarakoon and Seran, 2023). Organic manures play a part in residual effect of organic nitrogen and phosphorus in soil, supplying micronutrients, decreasing nitrogen leaching loss and phosphorus fixation (Chen, 2006). However, farmers do not prefer to utilize the organic fertilizers in crop cultivation because they release nutrients slowly compared to inorganic fertilizers but it could be available even at later stage. Change in the soil pH has a remarkable effect on decomposition of organic manures (Seran *et al.*, 2011) to discharge the nutrients to the soil.

The usage of household wastes as organic fertilizers in crop cultivation diminishes the waste growing into landfill (Wazir *et al.*, 2018). Tea is an internationally popular beverage which directs to a considerable accumulation of municipal waste. About 5% nitrogen, 5% phosphorus and 3% potassium are present in tea waste and it reduces pH of alkaline soils (Morikawa and Saigusa, 2008). Chicken eggshell as a byproduct of the egg product industry creates severe problems to the environment because it is also a waste (Zarea and Karimi, 2022). Use of eggshell wastes as organic fertilizer is more valuable and economically significant (Htwe *et al.*, 2025). Further, when eggshell fertilizer is combined with vinegar and transformed into a liquid form, plants can efficiently absorb nutrients (Martinez-Alcantara *et al.*, 2016). Foliar fertilizer application typically provides an immediate supply of nutrients to the crop (Dananjana and Seran, 2022).

Cow manure is an agricultural waste, on the other hand it is an organic fertilizer resource (Zhang *et al.*, 2020). Animal waste can be used in vegetable crop cultivation to supply essential nutrients and to reduce the environmental pollution. Locally available organic animal manure provides macro- and micro-nutrients continuously to growing crops while improving soil health. Although the nutrient availability in cattle manure is comparatively lower than that of chemical fertilizers, it is an excellent soil amendment and contains substantial amounts of primary and secondary nutrients (Seran, 2018). Organic farming is becoming increasingly popular worldwide, including in Sri Lanka (Yasanthini and Seran, 2009). In rural areas, farmers normally use cattle manure in crop production. Nowadays, organic liquid fertilizers derived from organic waste are also used to enhance the crop production. In this regard, cattle manure combined with extract derived from household waste can be used in crop production to provide the required essential nutrients for increasing the crop yield. This study focused on assessing the effect of cattle manure with tea waste and eggshell extract derived from household waste as organic liquid fertilizer in okra cultivation under sandy regosol soil conditions.

MATERIALS AND METHODS

The study was conducted in the experimental area of Eastern University, Sri Lanka, in 2023, and the soil type was sandy regosol. The latitude of the experimental location is 81° 34' and the longitude is 7° 48'. The elevation is 100 m above mean sea level. The mean annual temperature was 30±2°C, while the mean rainfall ranged from 1,800 mm to 2,100 mm, and relative humidity varied between 60% and 90%. This experiment was carried out in a completely randomized design (CRD) with eight treatments (Table 1) and five replicates for each. In this experiment, cattle manure as a base application and organic liquid fertilizers (extracts) as top dressings were used to compare the growth and yield performance of okra. In T2 treatment (control treatment), application of chemical fertilizers as basal and topdressing was done according to the recommendation of the Department of Agriculture, Sri Lanka.

Table 1: Treatments used in this experiment

Treatment codes	Treatments (Soil application of fertilizers)	
	Basal application	**Top dressing**
T1	No fertilizer	No fertilizer
T2	Chemical fertilizers	Chemical fertilizers
T3	Cattle manure (CM)	No fertilizer
T4	Cattle manure (CM)	Tea waste extract
T5	Cattle manure (CM)	Egg shell extract
T6	Cattle manure (CM)	Egg shell with vinegar extract
T7	Cattle manure (CM)	Tea waste and eggshell extract
T8	Cattle manure (CM)	Tea waste and eggshell with vinegar extract

Preparation of tea waste and eggshell extract

For preparation of tea waste extract, boiled and discarded tea waste from kitchen waste was collected and dried at 70°C for 1 h in an oven. Then 100 g of tea waste was added to a plastic container containing one liter of water and kept for 48 h and then kept in a shady place. After that, the solution was filtered to obtain tea waste extract (1.01% N, 0.52% K_2O and 0.56 dS/m) thereafter it was diluted with water in 1:1 ratio then 100 mL of the diluted tea waste extract per plant was applied to the soil in each specific treatment.

For preparation of eggshell extract, eggshells were thoroughly washed with water, it was then oven dried under 70°C for 1 h. The dried eggshells were pulverized into a fine powder using a grinder. Then 100 g of powdered eggshell was mixed with water in 1:2 (w/v) ratio and kept for 24 h. The final volume was

adjusted to one liter by adding water. It was kept for another 24 h followed by filtering to get eggshell extract (0.13% N, 0.02% P_2O_5 and 0.42 dS/m) and diluting in 1:1 ratio then 50 mL of the diluted eggshell extract per plant was added to the soil of the particular treatments.

For preparation of eggshell treated with vinegar extract, eggshells were washed thoroughly with water then it was oven dried under 70°C for 1 h. The dried eggshells were pulverized into a fine powder using grinder. For preparing the eggshell treated vinegar fertilizer, the steps were followed as described by Anthony (2023). As previous studies reported, eggshells were mixed with vinegar in 1:9 ratio (one part of eggshells and nine parts of vinegar) as described by Anthony (2023) and in 1:1 ratio (one teaspoon of eggshells and one teaspoon of vinegar) by following Gary (2018) and the extract was diluted with water in different ways. In the present study, 100 g of powdered eggshell was mixed with household vinegar (4% acetic acid) in 1:2 ratio and kept for 24 h. Then, the volume was made up to one liter by adding water. The solution was kept for another 24 h followed by filtering to obtain eggshell treated with vinegar extract (0.11% N, 0.08% P_2O_5 and 0.92 dS/m) and diluting in 1:1 ratio then 50 mL of the diluted eggshell with vinegar per plant was used as soil application for the particular treatments.

Agronomic experiment

The experiment was carried out using the polybags. The polybags were randomly arranged in 60 cm × 60 cm spacing and they were filled with soil and then cattle manure was applied as basal fertilizer at the rate of 10 t/ha to the respective treatments (T3-T8) two weeks before seeding. Recommended chemical fertilizers [50 kg/ha urea, 195 kg/ha triple super phosphate (TSP) and 25 kg/ha muriate of potash (MOP)] were applied two days before seeding as basal fertilizer to T2 treatment. Seeds of okra variety, Haritha obtained from the Department of Agriculture, Sri Lanka were used in this study. The seeds were soaked in water for 24 h prior to seeding. Three seeds were planted in each polybag into a depth of 1.5 cm. After two weeks of seeding, only one vigorous healthy plant was maintained in each polybag. The recommended chemical fertilizers (urea, MOP) were added to T2 treatment as top dressing at 2nd week (50 kg/ha and 25 kg/ha) and 5th week (100 kg/ha and 50 kg/ha), respectively after seeding. Chemical fertilizers and cattle manure was applied to each plant based on the polybag size (0.15 m^2). Application of cattle manure alone or with tea waste and eggshell extracts was practiced to T3-T8 treatments (Table 1). The diluted tea waste (100 mL per plant) and eggshell (50 mL per plant) extracts were added to the soil four times at two weeks interval, starting from 2nd week of seeding according to the treatments. Irrigation was done twice a day for the first week then it was done depending on the rainfall and the water requirement of the soil. Weeding was done manually once in two weeks interval before the soil application of fertilizers.

Plant height, number of leaves per plant, leaf length and width, fresh and dry plant weights and also root length were measured as growth parameters and pod length and girth, number of pods per plant, fresh and dry single pod weights, number of seeds per pod, fresh seed weight and fresh pod weight per plant were measured as yield parameters. Okra pods were picked four times. Marketable pod yield was calculated based on the fresh pod weight. All the collected data was subjected to analysis of variance (ANOVA) for testing significant differences between treatments using Statistical Analysis Software (SAS 9.1 version). Treatment mean separation was performed using Tukey's test at 5% significant level.

RESULTS AND DISCUSSION

Plant height

In this study, the different fertilizer treatments had a significant (p<0.01) effect on the plant height (Table 2). In the 2nd week, higher plant height (13.66 cm) was observed in T6 treatment followed by T8 with 13.60 cm. A significantly low value (11.60 cm) was (p<0.05) exhibited in T1 treatment than T6 and T8 treatments. In the 4th week, T2 had the highest values for the plant height and the lowest value (13.10 cm) was in T1 treatment. Consecutively, in the 6th and 8th week, T1 treatment remained remarkably at its lowest value (16.68 cm and 21.80 cm respectively) compared to the other treatments except T3. Further, it was noted that there were no remarkable variations on height of plants applied with chemical fertilizers (T2) and organic fertilizers (T4 -T8). This is in agreement with Sial *et al.* (2019) that addition of tea waste increase in plant height owing to the presence of nitrogen, phosphorus and potassium. Vu *et al.* (2022) also mentioned that the application of eggshell powder increases plant height.

Table 2: Effect of organic fertilizers on plant height of okra plants

Treatments	Plant height (cm)			
	2nd week	4th week	6th week	8th week
T1	11.60±0.28^{b}	13.10±0.43^{b}	16.68±0.97^{b}	21.80±1.15^{b}
T2	12.50±0.32^{ab}	17.50±0.89^{a}	24.50±2.04^{a}	31.00±1.09^{a}
T3	12.44±0.23^{ab}	15.80±0.86^{ab}	19.40±0.40^{ab}	23.20±0.58^{b}
T4	13.28±0.26^{ab}	17.04±0.61^{a}	21.74±0.59^{a}	27.90±0.90^{a}
T5	12.24±0.29^{ab}	15.92±0.68^{ab}	22.96±1.01^{a}	31.80±0.20^{a}
T6	13.66±0.49^{a}	16.20±0.96^{ab}	24.70±1.31^{a}	28.20±1.06^{a}
T7	13.10±0.43^{ab}	16.10±0.84^{ab}	25.10±1.87^{a}	31.00±0.89^{a}
T8	13.60±0.56^{a}	17.00±1.09^{a}	24.00±1.60^{a}	31.20±1.06^{a}
F test	p<0.05	p<0.05	p<0.001	p<0.001

Means within a column followed by the same letter are not significantly different according to Tukey's multiple comparison test at the 5% significance level.

Number of leaves per plant

The number of leaves per plant was influenced by the application of different fertilizers as there was a significant variation (p<0.05) according to statistical analysis (Table 3). In the 2nd week, any substantial difference was not noted in the number of leaves among the different treatments. In the 4th week, T2 (6.4), T6 (6.8) and T8 (6.4) were observed to have considerably (p<0.05) higher number of leaves when compared to T1 (4.8). When considering 6th and 8th week after seeding, highest number of leaves was counted in T8 (10.4 and 9.0, respectively) and T1 treatment had the least values (8.0 and 7.0, respectively). This finding is consistant with the research outcomes of Makkar *et al*. (2015) who reported that application of eggshell powder is able to induce the number of leaves as the presence of macronutrient and micronutrient in eggshell calcium, phosphorus, magnesium and nitrogen greatly affect the growth parameters of a plant. The above finding is inline with the study by Chowdhury *et al*. (2016) who stated that tea waste is rich in n-triacontanol, a compound known for its ability to enhance tea plant growth.

Table 3: Effect of organic fertilizers on number of leaves of okra plant

Treatment	Number of leaves			
	2nd week	**4th week**	**6th week**	**8th week**
T1	4.0±0.1	4.8 ± 0.2^{b}	8.0 ± 0.1^{bc}	7.0 ± 0.3^{d}
T2	4.0±0.2	6.4 ± 0.2^{a}	9.4 ± 0.4^{ab}	8.6 ± 0.2^{abc}
T3	4.0±0.1	5.4 ± 0.4^{ab}	7.2 ± 0.4^{c}	7.8 ± 0.2^{bcd}
T4	4.0±0.1	5.6 ± 0.4^{ab}	7.4 ± 0.2^{c}	7.6 ± 0.2^{cd}
T5	4.0±0.0	6.2 ± 0.2^{ab}	8.4 ± 0.4^{bc}	8.0 ± 0.0^{abcd}
T6	4.2±0.2	6.8 ± 0.5^{a}	9.4 ± 0.6^{ab}	7.8 ± 0.2^{bcd}
T7	4.4±0.2	5.6 ± 0.2^{ab}	9.6 ± 0.5^{ab}	8.8 ± 0.2^{ab}
T8	4.4±0.2	6.4 ± 0.4^{a}	10.4 ± 0.4^{a}	9.0 ± 0.2^{a}
F test	p>0.05	p<0.05	p<0.001	p<0.001

Means within a column followed by the same letter are not significantly different according to Tukey's multiple comparison test at the 5% significance level.

Leaf length and width

There was a significant (p<0.01) disparity in the leaf length among the treatments (Table 4). TI treatment exhibited a significantly lower (7.20 cm) value of leaf length than the other treatments (T2-T8) when treated with different fertilizers. Higher leaf width was measured in T5 and the lowest was in T1 (9.13 cm). The obtained results can be supported by the result observed by Radha and Karthikeyan (2019) who noted that there was a positive correlation between the

leaf surface area of the cowpea plant and hen eggshell concentration. Further, Gurav and Sinalkar (2013) indicated that the incorporation of tea waste into chickpea resulted in an expansion of leaf width. This implies a positive influence of tea waste on the morphological characteristics of the plant leaves.

Table 4: Effect of organic fertilizers tea waste and eggshell powder with vinegar on leaf length and leaf width at 8th week after seeding

Treatments	Leaf length (cm)	Leaf width (cm)
T1	7.20 ± 0.55^{b}	9.13 ± 0.67^{b}
T2	9.80 ± 0.21^{a}	12.02 ± 0.22^{ab}
T3	9.60 ± 0.42^{a}	11.63 ± 0.55^{ab}
T4	10.20 ± 0.68^{a}	12.23 ± 0.76^{ab}
T5	10.90 ± 0.11^{a}	14.60 ± 0.40^{a}
T6	10.30 ± 0.32^{a}	13.66 ± 0.14^{a}
T7	11.00 ± 0.23^{a}	13.73 ± 0.50^{a}
T8	11.19 ± 0.45^{a}	13.33 ± 0.72^{a}
F test	$p<0.01$	$p<0.01$

Means within a column followed by the same letter are not significantly different according to Tukey's multiple comparison test at the 5% significance level.

Pod length and girth

In accordance with the interpreted results, significant differences in pod length ($p<0.001$) and pod girth ($p<0.01$) were observed on account of the implementation of different fertilizers (Table 5). Higher values in the pod length (13.03 cm) and girth (4.92 cm) were recorded ($p<0.05$) in T8 than those in T1 and T3 treatments. This result coincides with the outcome of a study carried out by Sarkar *et al.* (2022), as they encountered pod length and girth were enhanced in cowpea plants with the application of tea waste as it contains optimum amount of nutrients required for the fruiting attributes. The result is in line with the statement of Wazir *et al.* (2018) who reported that the application of high eggshell concentration increases the pod size of pea. Azmin *et al.* (2022) also reported that the interaction between vinegar and eggshell speeds up the dissolution process for enhancing the release of nutrients from the eggshell thus this improves the accessibility of nutrients for plants, enhancing their overall availability.

Number of seeds per pod and its fresh weight

There were significant effects on the number of seeds (p<0.01) and fresh seed weight per pod (p<0.05) from the different fertilizers applied (Table 5). T8 treatment had remarkably highest (p<0.05) number of seeds per pod (30) than other treatments. The fresh seed weight per pod ranged from 1.20 g (T1) to 2.28 g (T6). This is in accordance with Wazir *et al.* (2018) who pointed out that tea waste increased number of grains per pod and pod size in pea plants as a result of the existence of the important nutrients for plant growth. Moreover, the Sari *et al*. (2023) mentioned that the application of eggshell powder influenced on the growth and seed yield of soybean plants to a 25 g per plant dose.

Table 5: Effect of organic fertilizers on length and girth of pod, number of seeds and fresh seed weight of okra plant

Treatments	Pod length (cm)	Pod girth (cm)	Number of seeds	Fresh seed weight (g)
T1	10.18±0.28^{c}	3.98±0.10^{b}	27.0±0.7^{b}	1.20±0.03^{c}
T2	11.67±0.60^{abc}	4.54±0.27^{ab}	24.0±1.0^{b}	1.56±0.21^{bc}
T3	11.08±0.33^{bc}	4.17±0.09^{b}	24.0±0.7^{b}	1.68±0.08^{abc}
T4	11.48±0.27^{abc}	4.56±0.06^{ab}	25.0±1.0^{b}	1.80±0.11^{abc}
T5	12.17±0.44^{ab}	4.44±0.11^{ab}	25.0±0.3^{b}	2.12±0.10^{ab}
T6	12.38±0.37^{ab}	4.30±0.13^{ab}	26.0±0.9^{b}	2.28±0.25^{a}
T7	11.83±0.23^{abc}	4.29±0.15^{ab}	24.0±1.7^{b}	1.96±0.15^{ab}
T8	13.08±0.52^{a}	4.92±0.13^{a}	30.0±1.0^{a}	1.89±0.43^{ab}
F test	p<0.001	p<0.01	p<0.01	p<0.05

Means within a column followed by the same letter are not significantly different according to Tukey's multiple comparison test at the 5% significance level.

Fresh and dry pod weights

In this experiment, considerable differences in the fresh (p<0.001) and dry (p<0.01) pod weight were noted due to the application of different fertilizers (Table 6). T8 treatment was recorded (p<0.05) to have the higher individual fresh pod weight (11.12 g) than T1, T5 and T7 treatments but dry pod weight was also significantly high (1.15 g) in T8 compared to other treatments except T2 and T6 treatments. Further, it was noticed that T1 had significantly low values of fresh (6.86 g) and dry (0.62 g) pod weights than other treatments. Singh (2020) emphasized that tea is cost-friendly, organic manure and rich in important nutrients. Khairnar and Nair (2019) summarized that eggshell has nutritive

elements which can improve the fruit yield of crops. Anthony (2023) highlighted that the acid in the vinegar take out calcium and some trace quantities of phosphorus in the eggshells hence calcium and other elements are instantly absorbed by the plants to enhance root system and to induce fruiting.

Table 6: Effect of organic fertilizers on fresh and dry weights of single pod as well as number of pods per okra plant

Treatment	Fresh and dry pod weight (g)		Number of pods per plant
	Fresh weight	Dry weight	
T1	6.86±0.17^{c}	0.62±0.04^{c}	2.2±0.2^{d}
T2	10.48±0.28^{ab}	0.98±0.10^{ab}	3.8 ±0.2^{abc}
T3	10.07±0.33^{ab}	0.90±0.03^{b}	2.8±0.2^{cd}
T4	9.86±0.67^{ab}	0.89±0.04^{b}	3.6±0.2^{bc}
T5	9.10±0.55^{b}	0.87±0.05^{b}	4.4±0.2^{ab}
T6	10.04±1.01^{ab}	0.99±0.08^{ab}	4.6±0.4^{ab}
T7	9.14±0.30^{b}	0.83±0.06^{b}	5.0±0.3^{a}
T8	11.12±0.54^{a}	1.15±0.10^{a}	4.4±0.2^{ab}
F test	p<0.001	p<0.01	p<0.001

Means within a column followed by the same letter are not significantly different according to Tukey's multiple comparison test at the 5% significance level.

Number of pods per plant and its weight

There was significant (p<0.001) difference in total number of pods per plant as shown in Table 6. Highest number of total pods per plants was given by T7 while lowest total pod number was given by T1. Sarkar *et al*. (2022) stated that the total number of pods was increased with the addition of tea waste as an organic fertilizer for cowpea plants. The utilization of eggshell powder solution has proven to have a favorable influence on the overall pod number of soybean plants (Sari *et al*., 2023). According to the outcomes of this experiment, there was noteworthy (p<0.001) divergence in the fresh weight of pods per plant (Figure 1). It was observed that the value of total pod weight per plant was 48.92 g in T8 but it was statistically similar with the values recorded in T2, T5, T6 and T7 treatments. Significantly lower total pod weight per plant (15.02 g) was given (p<0.05) by T1 among the tested treatments. This is in line with Ma'mor *et al*. (2023) who stated when eggshell used for corn plants, a significant result was noted in corn fresh weight per plant. Application of milk tea waste with inorganic

fertilizer increased N, P and K contents in shoots and roots compared to the application of inorganic fertilizer alone (Sial *et al.,* 2019).

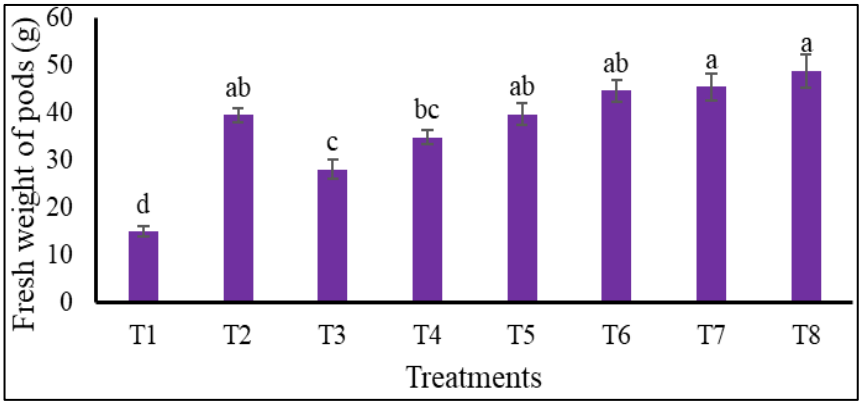

Figure 1: Effect of organic fertilizers on total pod fresh weight per plant

Root length

In light of the findings in this study, there was a significant (p<0.05) variation in the root length due to the difference in the soil amendments (Figure 2). A significantly higher root length (43.00 cm) was observed in T8 than other treatments except T4 and T5 treatments but the lowest value (17.60 cm) was recorded (p<0.05) in T1 among the treatments except T3. In accord with the above finding, Zou *et al.* (2023) noticed that the root length of lettuce (*Lactuca sativa* L.) seedlings was obviously increased with the application of green tea waste.

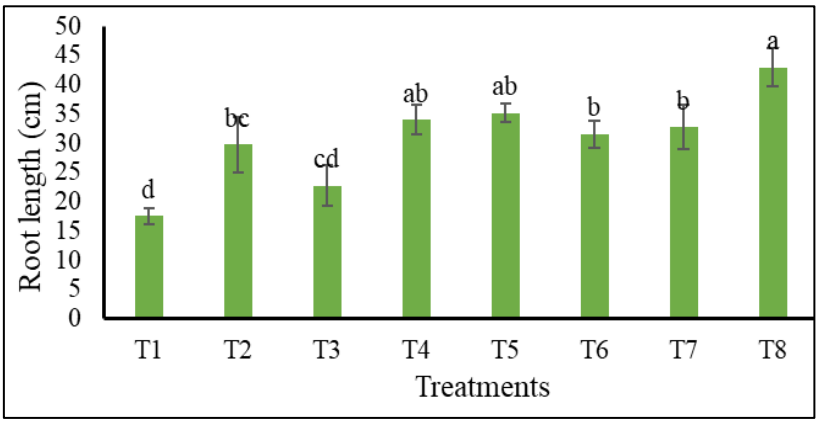

Figure 2: Effect of organic fertilizers on root length of okra plant at 9th week after seeding

Crop residue

As demonstrated in Table 7, there were significant (p<0.001) differences in fresh and dry weights of crop residue (leaf, stem and root) per plant at 9th week after seeding. Fresh weight was higher in T8 (47.10 g) followed by T7 (43.79 g) and its lowest value (16.30 g) was recorded in T1. As per the statistically analyzed results, higher dry plant weight was received from T8 (11.20 g) followed by T7 (10.18 g) and the lowest in T1 (2.16 g). With the evidence provided by Abdulghani (2012), increase in fresh and dry weight per plant was observed in Barley due to role of organic nutrients such as nitrogen, potassium and available phosphorus in tea waste. Muyassir *et al*. (2022) emphasized that mustard plants exhibited a favorable morphological response when subjected to the application of chicken eggshell flour in terms of both wet weight and dry weight because chicken eggshell flour, utilized as a soil amendment, consist of essential macro and micronutrients which has the ability to enhance both the growth and yield of crops. Furthermore, when eggshell fertilizer is treated with vinegar and in its liquid form, the plants can absorb nutrients easily without waiting for the fertilizer to be degraded (Martinez-Alcantara *et al*., 2016).

Table 7: Effect of organic fertilizers on the crop residue weights and marketable pod yield

Treatments	Crop residue weights (g)		Marketable pod yield (g/m^2)
	Fresh weight	Dry weight	
T1	16.30±3.24^{d}	2.16±0.23^{c}	41.72±2.87^{d}
T2	32.03±7.10^{abc}	6.05±0.91^{b}	110.11±3.77^{ab}
T3	17.29±3.27^{cd}	2.88±0.37^{c}	78.10±5.02^{c}
T4	25.70±3.64^{bcd}	4.72±0.76^{bc}	97.05±3.74^{bc}
T5	40.03±3.18^{ab}	7.19±1.25^{b}	110.54±5.95^{ab}
T6	32.97±7.39^{abc}	6.00±1.88^{b}	124.33±5.83^{ab}
T7	43.79±5.74^{a}	10.18±0.83^{a}	126.72±7.04^{a}
T8	47.10±04.56^{a}	11.20±0.93^{a}	135.89±8.60^{a}
F test	p<0.001	p<0.001	p<0.001

Means within a column followed by the same letter are not significantly different according to Tukey's multiple comparison test at the 5% significance level.

Marketable pod yield

When the marketable (immature) pod yield was calculated, a substantial (p<0.001) difference was observed in the values among treatments (Table 7). The highest pod yield (135.89 g/m^2) was recorded by T8 treatment followed by T7 treatment and the lowest (41.7 g/m^2) was given by T1 treatment. Further, it was

noted that pod yield in T2, T5 and T6 was statistically similar (p>0.05) with that in T8 and T7. The application of cattle manure with tea waste and eggshell extract increased the total pod yield of okra than use of cattle manure alone or cattle manure with tea waste extract. This statement is confirmed by Zahan *et al*. (2018) as they revealed that the administration of high doses of eggshell powder increased the fruit yield of tomato. Additionally, Alluqmani and Alabdallah (2022) noted that application of tea waste increased the fruit yield of strawberry (*Fragaria ananassa* cv. Tioga) owing to the presence of nitrogen, phosphorus and potassium in tea waste. Locally available cattle manure is generally used as soil amendment for increasing soil fertility. In the present study, it was further noted that tea waste extract contained relatively high nitrogen and potassium than eggshell extract whereas eggshell extract had somewhat high phosphorus content. As a result, marketable pod yield of okra was high in application of cattle manure along with tea waste and eggshell extracts as organic fertilizers in this study.

CONCLUSION

After analyzing the obtained results, it can be concluded that most of the growth and yield parameters was maximum in T8 treatment followed by T7 treatment. Further, it was noted that there was no significant difference on marketable pod yield among T2, T5, T6, T7 and T8 treatments. However, the marketable pod yields in T8, T7, T6 and T5 treatments were increased by 23.4%, 15.1%, 12.9% and 0.4%, respectively compared to T2 treatment (chemical fertilizer). Based on the finding in this study, locally available cattle manure with tea waste and eggshell treated vinegar extract (T8 treatment) can be used as an organic fertilizer to increase the marketable pod yield in okra cultivation under sandy regosol soil conditions. Suggestion for future study is to assess the specified treatment on yield and quality of okra under different soil conditions.

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