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Evaluation of Organic Manures and Recommended Chemical Fertilizers on Growth, Yield, and Economic Performance of Okra (*Abelmoschus esculentus* L.) under Irrigated Conditions

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Abstract: Okra is an economically important vegetable crop with high nutritional value, widely cultivated in tropical and subtropical regions globally. An experiment was conducted to assess the effect of eight treatments on the growth, yield, and economic performance of okra (*Abelmoschus esculentus* (L.) Moench) under irrigated conditions in the Kilinochchi District, Sri Lanka, during September to November 2023. The experiment was conducted in a Randomized Complete Block Design (RCBD) with three replicates. Eight treatments (T1–T8) consisting of different organic manure applications, and the Department of Agriculture (DOA)-recommended chemical fertilizers were applied, including a control treatment without organic manure. *Haritha* okra was used as the test variety. Growth parameters including plant height, dry weight, and number of leaves, and yield parameters including number of pods per plant, fresh pod weight, and shelf life were evaluated. Poultry manure applied at 460 g plant^{-1} (T2) recorded the highest plant height (31.4 cm), number of leaves (8.0 leaves plant^{-1}), dry pod weight (13.3 g plant^{-1}), fresh pod weight (130 g plant^{-1}), number of pods per plant (8 pods), and shelf life (5.7 days). Compared with the control treatment (T1), poultry manure increased plant height by 35.3%, fresh pod weight by 160%, and shelf life by 32.6%. No significant difference ($p \leq 0.05$) was observed between T2 and T5 (cattle manure: poultry manure, 230 g: 230 g plant^{-1}). The highest benefit-cost ratio was recorded in T2 and T5. It can be concluded that poultry manure at 460 g plant^{-1} was the most effective treatment for improving the growth, yield, and economic performance of okra under irrigated conditions.

Keywords: Okra, organic manures, shelf life, yield

1. Introduction

Okra (*Abelmoschus esculentus* (L.)) belongs to the family Malvaceae and is one of the important vegetable crops in Sri Lanka (Welbaum, 2024). Okra probably originated in Ethiopia and was cultivated by the ancient Egyptians by the 12th century. Its cultivation later spread throughout North Africa and the Middle East (Chanchal et al., n.d; Lamont, 1999; Pal, 2020). Okra is also known as Lady's Fingers, gombo, gumbo, quingombo, okro, ochro, bamia, bamie and quiabo (Gavint et al., 2018). It is a tropical plant that grows best in warm climates and available year - round, with a peak season during the summer. The pods are ready for harvest approximately in about 60 days when grown from seed. The pods must be picked 4 to 5 days after flowering, when they are about 4 inches in length, before they mature and toughen (Gavint et al., 2018). Okra comes in varying shades of green (and there is also a red variety), and can be smooth or ribbed. It is also a good source of vitamins A and C, as well as B-complex vitamins, iron and calcium (Kumar et al., 2017; Singh and Nigam, 2023).

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It is low in calories, rich in dietary fiber, and is fat-free. Okra is a plant that can thrive in both temperate and tropical climates, and in some regions, it can grow as a perennial.

In areas where it grows as an annual, it continues to produce pods even after pruning at 4 feet in height (Laméris, 2023), until the temperature drops too low. Okra is a warm-season crop that thrives in hot and humid climates. It requires full sun and a long growing season with temperatures consistently above 15 °C (59 °F) to produce a good crop. The ideal temperature ranges for growing okra are between 22–35 °C (71.6–95 °F), with night-time temperatures above 15 °C (Welbaum, 2024). It is important to note that okra is sensitive to frost and temperatures below 12 °C (53.6 °F) (Welbaum, 2024). In cooler climate, it is best to start okra indoors or wait until the soil and air temperatures are consistently warm before planting outside. The different parts of the okra plant, such as the leaves, seeds, pods, flower buds, shoots, and calyces, are all edible. In the dry and intermediate zones of Sri Lanka, it can be grown as a rain-fed crop in highlands during the Maha and Yala seasons. In Sri Lanka, it is grown throughout the year, making it popular among farmers. At present, it is cultivated successfully in Hambantota, Kurunegala, Rathnapura, and Matale districts and is spreading into Anuradhapura, Puttalam, Matara, Badulla, and Monaragala districts. The young pods are consumed, while the leaves are considered a delicacy in India and Africa. The nutrient level of okra is very high, with fiber and minerals, especially calcium and iodine, present in immature pods. Okra plays an important role in controlling thyroxine-related diseases due to its calcium and iodine content. The average yield is about 10-15 metric tons per hectare (DOA, 2015).

In the Northern Province of Sri Lanka, okra is cultivated in 1,214 hectares of land, and its production was 12,140 tons (Vavuniya: 327 hectares, Mullaitivu: 448 hectares, Kilinochchi: 454 hectares, Mannar: 170 hectares, and Jaffna: 135 hectares) (DOA, 2015). In Sri Lanka, four recommended varieties of okra are available, such as MI5, MI7, OKH1, and *Haritha* (Department of Agriculture Sri Lanka). *Haritha* is a newly selected variety released in 1993. Even though several varieties are available, the selection of a proper variety is extremely important to obtain a good yield. The *Haritha* variety is most preferred by farmers due to its short maturity period (50-60 days), ability to be cultivated in both seasons with low rainfall or irrigation, and moderate yield potential. The average yield is about 10-15 t/ha, while *Haritha* can produce up to 30 t/ha under suitable conditions. Considering farmers' practices, low yield, high fertilizer cost, and short shelf life are major problems faced by farmers in Kilinochchi and Mullaitivu districts. The *Haritha* variety is the commonly cultivated variety in these areas (Department of Agriculture, Sri Lanka).

Nutrient management plays an important role in improving okra productivity. The use of organic manures has gained increasing attention due to their potential to enhance soil fertility, improve soil physical properties, reduce dependency on chemical fertilizers, and improve crop quality. Therefore, this study was conducted to comparatively evaluate the effects of different organic manures and the Department of Agriculture (DOA)-recommended chemical fertilizers on the growth, yield, and economic performance of okra (*Abelmoschus esculentus* (L.)) under irrigated conditions.

2. Materials and Methods

A field experiment was carried out at a farmer's field in Kilinochchi during September to November 2023 to study the effect of different organic manures on the growth and yield performance of okra at Ramanathapuram, Kilinochchi, Sri Lanka.

2.1 Study Area

The study area was in a farmer's field at Ramanathapuram, Kilinochchi District, (approximately 9.39° N, 80.40° E), which is situated in the northern part of the country. It is in the Agro-ecological Region DL3. The average elevation of the study area is about 67 m above mean sea level. The soil was well-drained and clay loam in texture. The mean annual rainfall ranges from 1,040 mm to 1,560 mm, while the mean minimum and maximum temperatures range from 28 °C to 33 °C, respectively. During the experimental period (September to November 2023), the field was maintained under irrigated conditions. Prior to the experiment, the land had been cultivated with seasonal agricultural crops. Baseline soil chemical properties were not determined before the establishment of the experiment. Yellow latosols make up most soils in Kilinochchi District (approximately 36-40 % of the total land area). The experimental field had been used for crop production prior to conducting the experiment, however, there was no prior available information regarding previous agricultural activity in the field. No baseline information on soil characteristics (i.e. soil pH, electrical conductivity (EC), organic matter, total nitrogen, available phosphorus, exchangeable potassium and cation exchange capacity (CEC)) was collected prior to beginning the experiment. The evaluation of treatment effects was based upon crop performance relative to their original conditions prior to commencing the experiment.

2.2 Experimental design and Treatments

The experiment was conducted in a Randomized Complete Block Design (RCBD) with three replicates. The experimental field consisted of three blocks (replications), and each block was divided into eight plots corresponding to the eight treatments, resulting in a total of 24 plots in the experiment. Each plot measured 3 m × 3 m and there was no buffer zone. The treatments used in the study are presented in Table 1.

The DOA recommended chemical fertilizer treatment (T8) was included as a standard check treatment to compare the effectiveness of different organic manure applications with the recommended fertilizer practice. The control treatment (T1) represented the absence of both organic manure and chemical fertilizer, while T8 represented the conventional fertilizer recommendation. The performance of organic manure treatments was evaluated relative to both the untreated control and the recommended chemical fertilizer treatment. The organic manures used in the experiment were obtained from locally available sources. Poultry manure, cattle manure, and goat manure were applied according to the treatment structure.

Table 1. Treatments and their specific codes

Treatments	Treatment Code
Control (Without Organic Manures)	T_1
Poultry Manure 460 g/ Plant	T_2
Cattle Manure 460 g/Plant	T_3
Goat Manure 460 g/Plant	T_4
Cattle Manure : Poultry Manure 230 g : 230 g /Plant	T_5
Cattle Manure : Goat Manure 230 g : 230 g /Plant	T_6
Poultry Manure: Goat Manure 230 g : 230 g/Plant	T_7
DOA recommended chemical fertilizer: basal Application of 2.70 g urea + 10.53 g TSP + 1.35 g MOP plant^{-1}, followed by top dressings of 2.70 g urea + 1.35 g MOP plant^{-1} at 2 weeks after planting (WAP), 5.40 g urea + 2.70 g MOP plant^{-1} at 5 WAP, and 5.40 g urea + 2.70 g MOP plant^{-1} at 8 WAP	T_8

2.3 Selection of the variety

The okra variety *Haritha* (V1) was selected for this experiment due to its suitability for both Yala and Maha seasons in the dry zone and its preference by farmers. The details of the *Haritha* variety are presented in Table 2.

Table 2. Details of Haritha variety

Characters	Details
Seed type	Local
Seed rate	1.8 kg per acre (9500-10000 plants/acre) Vigorous
Plant type	Medium height
Color of foliage	Yellowish Dark green
Harvesting time	45 days after planting
Pod length	Medium

2.4 Land preparation

Land preparation is the most important cultural practice for the proper establishment of seedlings. A moist and weed-free soil condition is required to provide better contact between the seed and soil (Todkar et al., 2025). Initially, ploughing and hoeing were done to obtain a fine tilth condition in the field. At the site, three blocks were located parallel to each other. Each block contained eight treatment plots, giving a total of 24 plots in the experiment and the size of each plot was 3 m × 3 m. The plots were leveled using a mamoty. Irrigation channels were prepared parallel to the plots. The land was finally leveled using a mamoty for seed planting.

2.5 Field planting and Gap filling

The seeding depth depends on soil moisture, soil type, and seed size. The seeds were soaked in captan fungicide 50% WP (wettable powder) for 2 h and sown at the recommended spacing of 90 cm × 60 cm at a depth of 2–3 cm. A total of 16 plants were maintained in each plot, and the experiment consisted of 24 plots, resulting in a total plant population of 384 plants. The okra plant population was maintained at approximately 18,500 plants per hectare. Gap filling was carried out two weeks after field planting using healthy seedlings of the same age maintained in cups.

2.6 Irrigation

Proper soil moisture is important for good and uniform germination. Sufficient moisture is essential during the germination and flowering periods (Hou et al., 2022). A basin irrigation system was practiced in the plots. At the initial stage, plots were irrigated at 4-day intervals to maintain favorable soil moisture conditions and ensure maximum germination. After that, the irrigation interval was increased to 7–10 days depending on soil moisture conditions and crop water requirements. Irrigation was continued throughout the cropping period to maintain adequate soil moisture and avoid moisture stress during plant growth and pod development.

2.7 Weed Control, Fertilizer Application and Pest and Disease Control

Weed control was carried out manually at two-week intervals after seed germination to minimize weed competition during crop growth. Organic manures and chemical fertilizers were applied according to the treatment structure presented in Table 1. No synthetic pesticides were applied during the experimental period. Neem oil was sprayed (approximately 2–3 mL L^{-1} of water (0.2–0.3%), using a hand-held sprayer) on the foliage at 10-day intervals as a preventive measure against pest infestations. Crop management practices were carried out uniformly for all treatments throughout the growing period.

2.8 Sampling and Recording of Parameters

Growth and yield parameters were recorded from ten randomly selected plants from each plot out of the total 16 plants maintained per plot. Okra plant height (cm) was measured at weekly intervals after planting using a measuring tape. The number of leaves per plant was also recorded at weekly intervals from the selected plants. The following yield parameters were measured at the time of harvesting: fresh pod weight (g plant^{-1}), number of pods per plant, dry pod weight (g plant^{-1}), and shelf life (days).

Fresh pod weight was measured immediately after harvesting using a digital balance. The total number of marketable pods harvested from each sampled plant was recorded and expressed as the number of pods per plant. For dry weight determination, harvested pods were oven-dried at 70 °C until a constant weight was obtained and then weighed using a digital balance. Shelf life was evaluated under room temperature conditions (approximately 28 ± 2 °C) by recording the number of days taken for harvested pods to show visible signs of deterioration such as wilting, discoloration, shriveling, or loss of marketable quality.

2.9 Data Analysis

Analysis of variance (ANOVA) was performed using the statistical package SAS (9.1). Mean separation was done using Duncan's Multiple Range Test (DMRT) at $p = 0.05$ (Pecchia et al., 2014). Economic performance was evaluated using the benefit-cost ratio (BCR), which was calculated by dividing the gross income obtained from pod yield by the total production cost associated with each treatment.

3. Results and Discussion

3.1 Growth Parameters

3.1.1 Plant Height

Plant height is an important growth parameter that reflects the vegetative growth and nutrient status of the crop (Makinde et al., 2022). The effect of different treatments on plant height of okra at five weeks after planting was observed. The highest plant height (31.4 cm) was recorded in T2 (poultry manure 460 g plant^{-1}), while the lowest plant height (23.2 cm) was observed in T1 (control treatment).

Excellent results of T2 can be attributed to improved nutrient availability and better soil conditions following agricultural applications of poultry manure as opposed to synthetic fertilizers. Organic manures enhance ability of soil to promote rapid water absorption, maintain moisture content, create excellent growing conditions for microorganisms, and ultimately lead to greater access and uptake of nutrients by plants, resulting in enhanced plant growth. These findings are consistent with prior work by Aboyeji (2022) who also reported increased vegetative growth in okra plants due to the application of organic sources of nutrients. Poor growth of plants in the control treatment may also result from limited access to nutrients throughout the growth period. Results clearly show that under the current conditions, poultry manure is more effective than using the DOA-established fertilizer application rate to produce the most vegetative growth.

3.1.2 Number of Leaves per Plant

The effect of different treatments on the number of leaves per plant is presented in Figure 1. The highest number of leaves (8 leaves plant^{-1}) was recorded in treatment T2 (poultry manure 460 g plant^{-1}), while the lowest number of leaves (4.1 leaves plant^{-1}) was observed in T1 (control treatment).

The increased leaf production observed in T2 may be attributed to improved nutrient availability resulting from poultry manure application. Adequate nutrient supply enhances leaf initiation, expansion, and photosynthetic activity, which contribute to overall plant growth. Organic manures release nutrients gradually throughout the crop growth period and improve soil biological activity. Similar findings were reported by Aziz (2023), who found that organic nutrient sources significantly improved leaf development and vegetative growth in okra. The lower number of leaves observed in the control treatment may be associated with nutrient deficiency, which limits vegetative development. These findings suggest that poultry manure was more effective than the DOA-recommended fertilizer treatment in promoting leaf production.

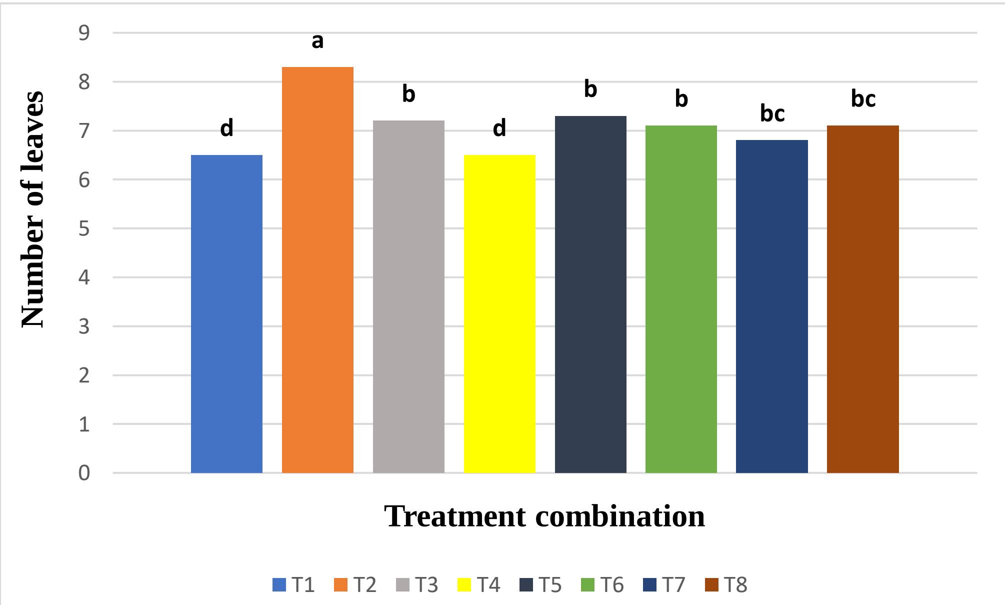

Figure 1: Mean number of leaves per plant among different treatments. Bars with different lowercase letters indicate significant differences among treatments according to Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$

3.1.3 Dry weight of pods per plant

Dry pod weight per plant differed significantly among treatments at p =0.05. The highest dry pod weight (13.3 g plant^{-1}) was recorded in treatment T2, while the lowest dry pod weight (6.5 g plant^{-1}) was observed in T7. Figure 2 shows the mean dry pod plant under different treatments.

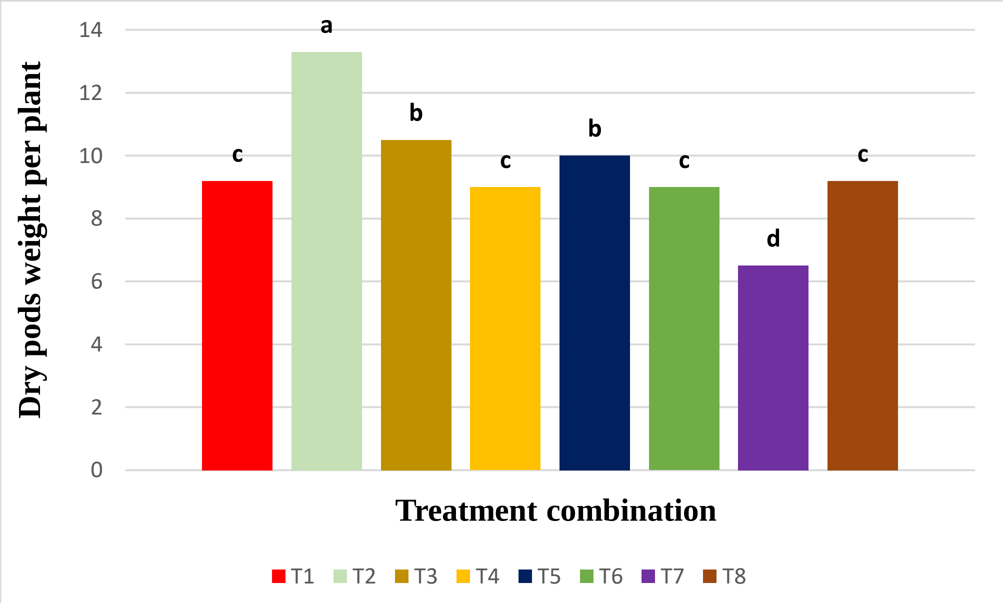

Figure 2: Mean dry pod weight per plant among different treatments. Bars with different lowercase letters indicate significant differences among treatments according to Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$

The higher weight of the pods at the end of the growing season could be due to increased nutrient availability, increased photosynthetic activity, and greater accumulation of dry matter in the pods because of both organic and inorganic nutrients. The use of organic manures will help retain moisture and maintain a constant supply of nutrients throughout the growing season, which contributes to increased biomass and yield of okra. The lower weight recorded for the other treatments may be due to lower levels of nutrients available and lower production levels of photosynthetic material. This supports the conclusion that using poultry manure was more effective than the fertilizer recommended by DOA in increasing the dry weight of the pods.

3.2 Yield Parameters

The yield of okra depends on several factors like plant density per hectare, pods per plant, and pod weight. For the plant density at 90 cm x 60 cm spacing, plant density is estimated to be around 18,518 plants ha^{-1}. Thus, fresh pod weight, dry pod weight, pods per plant, and shelf life of pods were considered as indicators of crop yield. These factors have commonly been used in other research works on okra (Makinde et al., 2022; Welbaum, 2024).

3.2.1 Fresh Pod Weight per Plant

The effect of different treatments on fresh pod weight per plant is presented in Figure 3. The highest fresh pod weight (130 g plant^{-1}) was recorded in T2, while the lowest fresh pod weight (50 g plant^{-1}) was observed in the control treatment (T1).

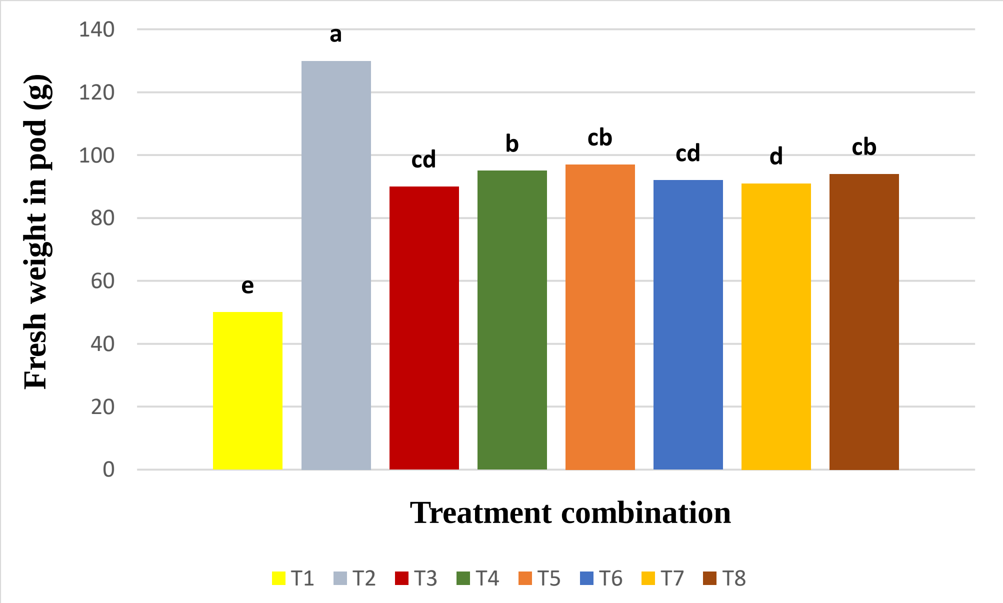

Figure 3: Mean fresh pod weight per plant among different treatments. Bars with different lowercase letters indicate significant differences among treatments according to Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$

The weight of the fresh pods is one of the most important components of yield for okra and is affected by the nutrients available to the plant during the growth period of the pod. The T2 treatment produced more pod weight than the control treatment because of the additional nutrients supplied by the poultry manure compared to the control treatment. Poultry manure is beneficial to nutrient availability and retention of soil moisture, which contributes to pod growth. The findings of Ekwere et al. (2021) support this conclusion, as they found that poultry manure increased pod weight in okra. The low weight of the fresh pods in the control treatment was likely due to a lack of nutrients throughout the entire growing season. Therefore, poultry manure is more effective for producing fresh pod yields compared to the fertilizer recommended by the Department of Agriculture.

3.2.2 Number of Pods per Plant

The number of pods per plant was significantly affected by the treatments. The highest number of pods per plant (8 pods plant^{-1}) was recorded in T2, while the lowest number of pods per plant (4 pods plant^{-1}) was observed in T1. The DOA-recommended fertilizer treatment (T8) produced fewer pods than T2 (Figure 4).

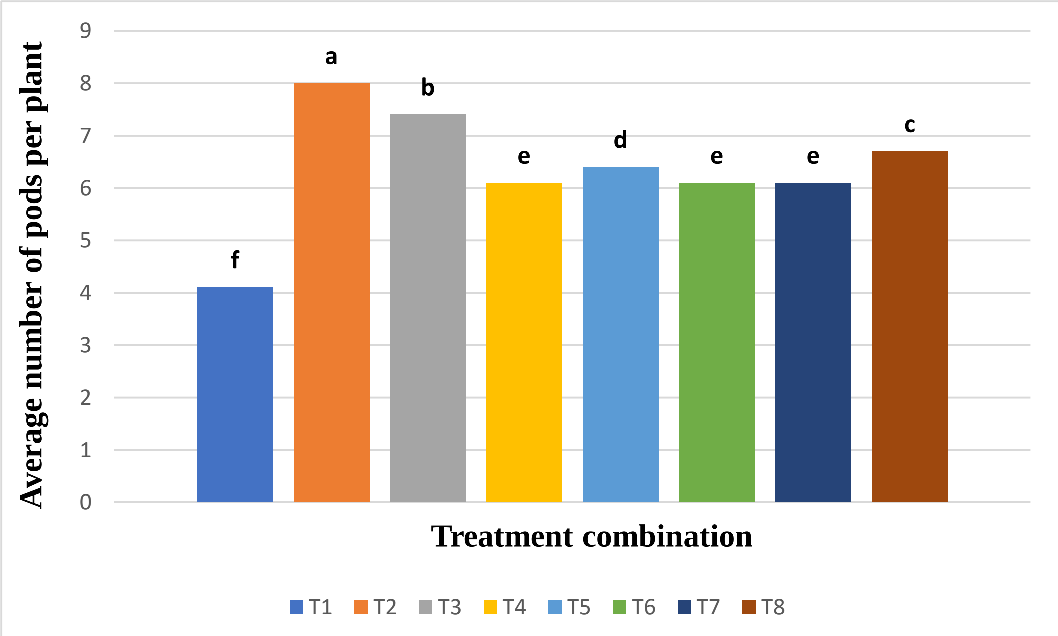

Figure 4: Mean number of pods per plant among different treatments. Bars with different lowercase letters indicate significant differences among treatments according to Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$

An improved availability of nutrients for plant growth, which leads to better vegetative development of the plants that support the formation of flowers and pods, is the reason there were more pods produced by the plants treated with poultry manure. Organic manures increase soil fertility and improve nutrient uptake throughout the entire growth cycle of the crop. Shahriazzaman (2014) has also reported that poultry manure improved the yield of okra due to an increased number of fruits. The control plots had fewer pods due to limitations on nutrient availability inhibiting reproductive growth of the crop. The results demonstrate that poultry manure produced a greater number of pods than the DOA-recommended fertilizer.

3.2.3 Shelf Life

There was a significant difference in shelf life with T2 having the highest shelf life of 5.7 days as well as T1 had the lowest shelf life of 4.3 days. Shelf life was assessed by determining the number of days for pods to lose their marketable condition under ambient room temperature based on the criterion of visual quality characteristics (Figure 5). The DOA-recommended fertilizer treatment (T8) showed moderate shelf-life performance. The longer shelf life in T2 might be due to greater balance and better quality in the nutrients on the pod caused by poultry manure use. Improved plant health through organic sources of nutrients helps develop the pod, which will affect how good the pod will be after it is harvested. The same has been shown with some vegetable crops as organic nutrient management can improve characteristics of postharvest and storage life. The short shelf life seen in the control treatment could be due to a lower quality pod developed by having lower nutrient levels throughout growing season of the crop. Poultry manure resulted in a longer shelf life of okra pods compared to fertilizer recommendations from the DOA.

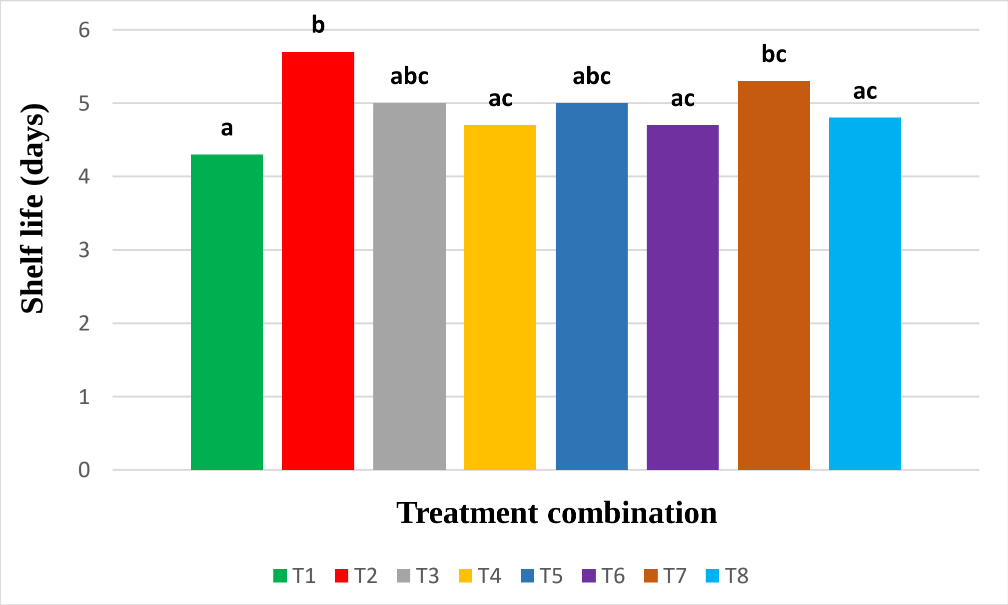

Figure 5: Mean shelf life (days) of okra pods among different treatments. Bars with different lowercase letters indicate significant differences among treatments according to Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

3.3 Economic Analysis

The economic analysis revealed that treatment T2 recorded the highest benefit-cost ratio (BCR) of 0.46. Although several treatments improved growth and yield performance compared with the control, poultry manure (460 g plant^{-1}) provided the highest economic returns. The higher BCR observed in these treatments was mainly due to increased pod yield and improved marketable produce. The control treatment recorded the lowest economic return due to poor growth and yield performance. Therefore, poultry-manure application can be considered a more profitable nutrient management option for okra cultivation under irrigated conditions.

4. Conclusions

The application of organic manures significantly influenced the growth, yield, shelf life, and economic performance of irrigated okra. Among the treatments evaluated, poultry manure applied at 460 g plant^{-1} (T2) produced the highest plant height, leaf number, fresh pod weight, dry pod weight, number of pods per plant, shelf life, and overall profitability. T2 also surpassed the unfertilized control and the DOA-recommended chemical fertilizer treatments under the experimental conditions of this trial. This demonstrates the potential of T2 as an effective nutrient source for growing okra. However, these findings should be interpreted with caution because baseline soil fertility data were not determined before the experiment. In addition, the physicochemical properties (i.e., pH, electrical conductivity, etc.) of the organic fertilizers were not analysed prior to treatment. Consequently, the mechanisms underlying treatment responses and the dynamics of nutrient movement could not be fully explained. Therefore, future studies should incorporate a complete characterization of both soils and organic fertilizers before the experiments begin. Additionally, future research should be conducted across different seasons and locations within various agro-ecosystems. This will help determine whether the identified treatments provide consistent results and can support fertilizer recommendations for the sustainable production of okra.

Declaration of Generative AI and AI-Assisted Technologies

During the preparation of this manuscript, the authors utilized ChatGPT (GPT-5.3) strictly to refine sentence structure across all sections to improve readability and linguistic accuracy. The authors reviewed, edited, and revised all generated text to ensure it accurately reflects their original intellectual work and findings. The authors independently verified all data, analysis, and citations, and assume full accountability for the final published content.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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