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Evaluation of Three Okra (*Abelmoschus esculentus* L. Moench) Varieties in Response to Organic and Inorganic Fertilization

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ABSTRACT

A field experiment was conducted during the Kharif-2 season of 2022 at Noakhali Science and Technology University to examine the impact of organic and inorganic fertilizers on the growth and yield of okra. A factorial experiment involving two factors was implemented. Factor A consisted of three varieties of okra *viz.*, V_1- Green Finger, V_2- BARI Dherosh-1, V_3- a local variety, along with factor B consisted of three treatments *viz.*, T_1- Organic fertilizers (Vermicompost @ 5 t/ha + Farmyard Manure @ 5 t/ha), T_2- Chemical fertilizers (NPK: 80:60:60 kg/ha), and T_3- Control. The experiment was laid out in a Randomized Complete Block Design with three replications. Data were collected on different vegetative and yield parameters. Results revealed that the Green Finger variety exhibited higher growth and yield in comparison to both the BARI Dherosh-1 and the local variety. The organic fertilizer treatment demonstrated greater outcomes in contrast with chemical fertilizers and without fertilizer. Therefore, the treatment combination V_1T_1, consisting of the Green finger variety with a Vermicompost @ 5 t/ha + Farmyard Manure @ 5 t/ha, resulted in the maximum okra production of 14.15 tons/ha. The experiment's findings led to the inference that the utilization of vermicompost and FYM in combination is an effective organic fertilizer in comparison to chemical fertilizers. Therefore, it is imperative to promote the appropriate utilization of organic sources of nutrients in the production of okra to enhance growth and increase production.

1. Introduction

Okra, commonly referred to as *Abelmoschus esculentus* L. Moench or lady's finger, has significant importance as a vegetable throughout the tropical and sub-tropical regions of the world (Badrie, 2016). Being a short-duration vegetable crop, it is one of the most common summer vegetables in Bangladesh (Zannat et al., 2023). In 2020-21, Bangladesh produced 70242 metric tons of okra from 12189 ha of land at an average yield of 5.7 tons/ha (BBS, 2021). The amount of okra production in Bangladesh is comparatively lower as compared to other countries. Fertilizers play a crucial role in promoting the initial vegetative growth and overall production of okra. The application of fertilizers in soil has the potential to promote crop productivity and improve the nutrient status of the soil. The application of organic and inorganic fertilizers not only maintains soil fertility but also improves the physical and biological properties of the soils (Atijegbe et al., 2014; Rana et al., 2020). The use of organic fertilizers to fulfil the nutritional needs of crops is anticipated to become an imperative practice in the future to promote sustainable agriculture. The application of organic soil amendments generally leads to improvements in the biological, chemical, and physical attributes of the soil along with conserving the moisture retention capacity, resulting in enhanced crop productivity and maintaining the quality of crop (Ogunsola et al., 2012). Although organic fertilizers may provide lower amounts of plant nutrients compared to inorganic fertilizers, the presence of growth-promoting elements such as enzymes and hormones, besides plant nutrition, make them crucial for enhancing soil fertility and production (Dileep, 2005). Among organic fertilizers, vermicompost is regarded as a valuable organic nutrient source due to its comparatively higher amount of plant nutrients in comparison to common organic manures (Khan et al., 2023). Additionally, it contains growth-promoting substances that promote growth. Hence, the utilization of vermicompost not only leads to an increase in crop output but also contributes to the enhancement of

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soil quality through the improvement of fertility, water retention capabilities, and microbial populations (Kumar et al., 2023). Farmyard manure (FYM) has been found to have a longer-lasting impact on soil fertility compared to inorganic fertilizers. Farmyard waste contains a comprehensive array of macro and micronutrients that are essential for optimal plant growth. Nevertheless, it functions as a storage facility for nitrogen, phosphorus, and potassium, so aiding in the prevention of nutrient leaching. This particular source exhibits a high concentration of organic carbon. Furthermore, the preservation of organic matter within the soil plays a crucial role in enhancing the nutritional and structural characteristics of soils (Kumar et al., 2023). The growth, yield, and quality of okra are significantly impacted by the appropriate timing and dosage of fertilizer treatment. The nutritional needs of okra can be met by the utilization of either organic or inorganic fertilizers. Insufficient quantities of these essential minerals lead to poor performance of the okra plant, exhibiting restricted growth and ultimately resulting in diminished crop output. The increasing popularity of vegetables cultivated using organic fertilizers can be attributed to their reduced chemical residue levels and enhanced flavor (Madan and Sanjeev, 2016). Consequently, the aim of this study was to investigate the response of selected okra varieties to different nutrient sources as well as their combined influence on okra growth and yield performance.

2. Materials and Methods

2.1. Study site and soil properties

A field experiment was carried out at the Agriculture research field, Noakhali Science and Technology University, Noakhali, Bangladesh during the period from May to August 2022 (Kharif-2 Season). The experimental area is located in the agroecological zone of Young Meghna Estuarine Flood Plain (AEZ-18). The experimental site is medium-high land with fairly leveled topography. The soil exhibited a sandy loam in texture and had a pH value of 6.7 and electrical conductivity <2 dS/m which was measured by a pH meter (Hach sensION+ PH1 Basic Portable pH Meter) and an EC meter (Hach sensION+EC7) in the laboratory of the Department of Agriculture. The general fertility of the soil is medium but low in organic matter *viz.* organic matter (0.068%), total nitrogen (0.04%), available phosphorous (27.89%), and potassium (0.18%) (Source: Soil Resource and Development Institute (SRDI), Noakhali).

2.2. Experiment design and treatments

The factorial experiment involving two factors was executed using a randomized complete block design (RCBD) with three replications. Factor A consisted of three varieties of okra *viz.,* V_1- Green Finger (a hybrid variety with an average fruit number is 50-55 per plant), V_2- BARI Dherosh-1 (an average fruit number is 25-30 per plant and an average yield is 14-16 t/ha), V_3- a local variety, along with factor B consisted of three treatments *viz.,* T_1- Organic fertilizers (Vermicompost @ 5 t/ha + Farmyard Manure (FYM) @ 5 t/ha), T_2- Chemical fertilizers (NPK: 80:60:60 kg/ha), T_3- Control. The whole field was divided into three blocks and each block consisted of 9 plots. A total of 9 treatment combinations were assigned at random within a block. The total number of unit plots was 27 which required 20 m^2 of land. Each plot size was 90 cm × 60 cm (0.54 m^2) with 50 cm spacing between two plots.

2.3. Seed sowing and treatment imposition

The land was prepared in the conventional method. Plots allotted under T_1 were treated with Vermicompost @ 5 t/ha + FYM @ 5 t/ha during land preparation and two weeks before seed sowing. Experimental plots under T_2 were fertilized with Urea, TSP, and MoP @ 80:60:60 kg/ha. The entire amounts of Triple Super Phosphate (TSP), and Muriate of Potash (MoP) were applied during land preparation. Urea was applied in three splits at basal, as top dressing at 35 and 60 days after sowing (DAS). After land preparation, two healthy seeds were dibbled 2 cm deep on 15th May 2022 maintaining a uniform distance of 45 × 60 cm in two successive hills. Two weeks after sowing, the seedlings were thinned to one seedling per hill.

2.4. Intercultural operation

The implementation of essential intercultural practices was undertaken during the cropping season to facilitate the optimal growth and development of the plant. Following the process of germination, a single healthy seedling was selected for cultivation in each respective area, while the remaining seedlings were eliminated. Three rounds of weeding were conducted in order to maintain weed-free conditions in the plots. Light irrigation was given just after sowing the seed. A week after sowing the requirement of irrigation was envisaged through visual estimation. Stagnant water was effectively drained out at the time of heavy rain and no irrigation was applied.

2.5. Data collection

Three plants were randomly selected from five plants in each unit plot for collecting data. Growth and yield parameters such as plant height (cm), stem diameter (cm), leaf number, leaf length (cm), leaf breadth (cm), petiole length (cm), days required for first flowering (DAS), pod/ plant, single fruit length (cm), single fruit diameter (cm), single fruit weight (g), yield/ plot (kg), and yield/ ha (ton) were measured from the sample plants.

2.6. Data analysis

The data were subjected to statistical analysis using the analysis of variance (ANOVA) method. Mean differences were assessed using Tukey's HSD test at a significance level of $p<0.05$ using MSTAT-C statistical software.

3. Results and Discussion

3.1. Plant height

Notably, significant variations were observed among the varieties, treatments, and their interaction. The highest plant height was observed at 30, 45, and 60 days after sowing (DAS), with measurements of 18.95 cm, 40.28 cm, and 83.11 cm, respectively, in the Green finger variety (V_1) as compared to BARI Dherosh-1 and the local variety (Figure 1a). In the case of treatment, the highest plant height (19.65 cm, 37.91 cm, and 85 cm) was observed at 30, 45, and 60 DAS in treatment T_1 (Vermicompost @ 5 t/ha + FYM @ 5 t/ha) and the lowest one was observed in control (Figure 2a). The interaction between variety and treatment had also a significant impact on the plant height

(Table 1). The tallest plants were observed in Green Finger with vermicompost @ 5 t/ha + FYM @ 5 t/ha. Specifically, the plant heights recorded were 22.42 cm, 44.93 cm, and 95.27 cm at the respective time points. It exhibited statistical similarity to V_2T_1. In contrast, the plant height recorded in V_2T_3 was observed to be the shortest, which was statistically similar to V_3T_2 and V_3T_3. According to Akhter (2020) findings, the utilization of vermicompost as a treatment resulted in the greatest plant height measurements at 20, 40, and 60 DAS, with values of 19.31 cm, 82.28 cm, and 104.96 cm, respectively. A similar result was reported by Ceritoglu et al. (2018). Sadeghipour (2017) also reported that the highest plant height was attained when the plants were treated with 100% vermicompost. Consistent with the results obtained, the application of vermicompost enhanced the growth of chilli pepper plants (Narkhede et al., 2011) and tomato plants (Olle, 2016) which supported our research findings.

3.2. Stem diameter

The stem diameter was recorded at different stages of growth i.e. 30, 45, and 60 days after sowing (DAS). The Green finger variety (V_1) exhibited the highest stem diameter (3.14 cm) at 60 DAS, which was statistically equivalent to the BARI Dherosh-1 variety (V_2). Conversely, the local variety (V_3) showed the smallest diameter (2.26 cm; Figure 1b). At 60 DAS, the treatment T_1 (Vermicompost @ 5 t/ha + FYM @ 5 t/ha) exhibited the highest stem diameter of 3.21 cm, which was identical to T_2 and control had the lowest of 2.21 cm (Figure 2b). The treatment combination V_1T_1 exhibited the largest stem diameter (3.62 cm) which was statistically identical to V_1T_2, V_2T_1, and V_2T_2 treatment combinations. However, the local variety under control treatment had the shortest stem diameter (1.92 cm; Table 1). According to Olle (2016), the application of organic fertilizers resulted in a significant increase in stem diameter as compared to the control treatment. A similar finding was figured out by Sharma et al. (2015). Rekha et al. (2018) claimed that the application of 50% vermicompost improved the length of the shoot, internode, and the number of branches in chilli. It can be asserted that the utilization of organic fertilizers leads to a notable enhancement in stem diameter, hence validating our research findings.

3.3. Leaf number/plant

Number of the leaves was recorded at 30, 45, and 60 days after sowing (DAS) and significant variation was found. At 60 DAS, the Green finger variety (V_1) showed the highest number of leaves (14.11), while the local variety (V_3) exhibited the lowest number (10.78 cm; Figure 1c). In treatment T_1 displayed the highest leaf number of 14.11 at 60 DAS. Alternatively, T_3 exhibited the lowest leaf number of 10.33 (Figure 2c). In the case of the combination effect Green Finger with a mixture of vermicompost @ 5 t/ha + FYM @ 5 t/ha, demonstrated the highest leaf count (16.67) at 60 DAS. Besides, V_3T_3 and V_2T_3 exhibited the lowest leaf counts of 9 and 10.67, respectively (Table 1) which were statistically similar. Joshi et al. (2015) stated that the application of vermicompost increased the number of leaves, leaf area, leaf dry weight, and chlorophyll content of plants. A similar result was found by Arancon et al. (2004) in strawberries, Olle (2016) in tomatoes, Ansari and Kumar (2010) in okra, and Rekha et al. (2018) in chilli.

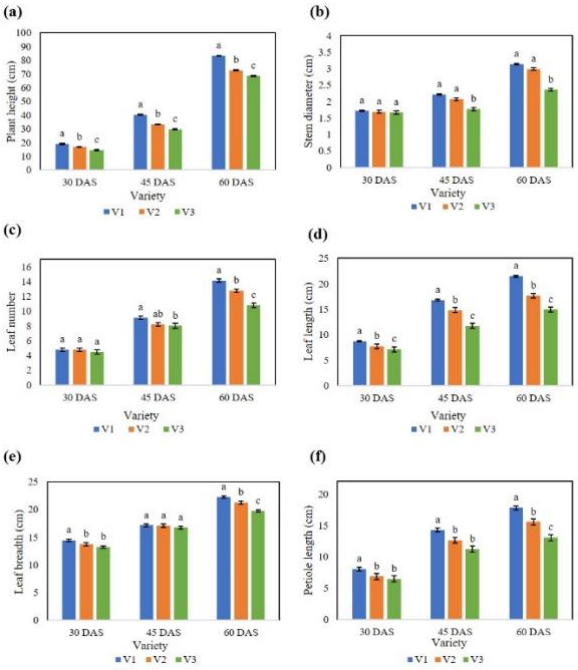

Figure 1: Varietal effect on vegetative traits of okra at 30, 45, and 60 days after sowing (DAS). (a) plant height (cm); (b) stem diameter (cm); (c) leaf number; (d) leaf length (cm); (e) leaf breadth (cm); (f) petiole length (cm); V_1: Green Finger; V_2: BARI Dherosh-1; V_3: a local variety. The values are the averages of three replicates ± SE (standard error). Different letters (a, b, c) show significant differences according to the homogenous subsets of Tukey's HSD test at a 0.05 level of significance.

3.4. Leaf length

A significant variation was found in the leaf length. The data was collected at three specific time points: 30, 45, and 60 days after sowing (DAS). At 60 days after sowing (DAS), the V_1 variety exhibited the longest leaf (21.43 cm), while the V_3 variety showed the shortest leaf (14.92 cm; Figure 1d). Regarding the treatment conditions, the T_1 exhibited the highest leaf length (21.60 cm), while the control treatment had the lowest leaf length (Figure 2d). A remarkable variance existed in the assortment of varieties and treatment combinations (Table 2). The treatment V_1T_1, consisting of a vermicompost @ 5 t/ha + FYM @ 5 t/ha mixture with Green figure variety, exhibited the highest recorded leaf length of 25.57 cm. At the same time, the treatment V_3T_3 showed the lowest recorded leaf length of 12.90 cm, which was equivalent to the V_2T_3 and V_3T_2 treatments. Singh and Chauhan (2009) described that the application of vermicompost and farmyard manure positively influences the leaf length and leaf width. Peyvast et al. (2008) observed a similar finding.

Table 1. Interaction effects of variety and treatment on plant height, stem diameter, and leaf number of okra.

Treatment combination	Plant height (cm)			Stem diameter (cm)			Leaf number		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
V_1T_1	22.42a	44.93a	95.27a	1.84a	2.44a	3.62a	4.67	12.00a	16.67a
V_1T_2	17.97b	40.37b	81.80c	1.82a	2.40a	3.37a	5.00	8.33b	14.33ab
V_1T_3	16.47bc	35.53c	72.28d	1.51b	1.80cd	2.42b	4.67	7.00b	11.33cd
V_2T_1	21.13a	38.67b	89.40b	1.86a	2.23ab	3.35a	4.33	9.33b	14.00abc
V_2T_2	16.03bc	32.57d	68.40d	1.73a	2.09abc	3.34a	5.67	8.00b	13.67bc
V_2T_3	12.97e	28.23e	60.37e	1.47b	1.91bcd	2.29bc	4.33	7.33b	10.67d
V_3T_1	15.40cd	30.13de	71.57d	1.81a	1.91bcd	2.66b	4.33	8.33b	11.67bcd
V_3T_2	14.43cde	31.30d	70.20d	1.76a	1.84cd	2.51b	4.33	8.33b	11.67bcd
V_3T_3	13.23de	27.30e	63.57e	1.46b	1.59d	1.92c	4.67	7.33b	9.00d
Level of significant	*	*	*	*	*	*	NS	*	*
SE (±)	0.47	0.57	0.89	0.04	0.08	0.08	0.40	0.47	0.54
CV (%)	4.96	2.88	2.06	3.88	6.57	5.10	14.94	9.57	7.45

* = Significant at 5 % level of probability, CV=Co-efficient of variations, SE (±) = Standard Error. V_1= Green Finger, V_2= BARI Dherosh-1, V_3= A local variety, T_1= Organic fertilizers (Vermicompost 50%+ Farmyard Manure 50%, @ 10 tons/ha); T_2= Chemical fertilizers (NPK- 80:60:60 kg/ha); T_3= Control, Here, values in the column having a similar letter (s) are statistically identical (Tukey's HSD test at $p<0.05$).

Table 2. Interaction effects of variety and treatment on leaf length, leaf breadth, and petiole length of okra.

Treatment combination	Leaf length (cm)			Leaf breadth (cm)			Petiole length (cm)		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
V_1T_1	9.40a	18.92a	25.57a	16.02a	19.65a	24.30a	9.60a	17.63a	19.20a
V_1T_2	9.03ab	18.53a	22.47b	14.70abc	17.15abc	21.98bc	8.33ab	13.37bc	17.17bc
V_1T_3	7.67cd	12.90bc	16.27cd	12.73ef	14.63cd	20.57cde	6.17bc	11.77bc	17.07bc
V_2T_1	8.27abc	18.60a	21.63b	15.18ab	18.20ab	23.25ab	8.07abc	14.73ab	17.70b
V_2T_2	8.00bc	13.77b	16.50cd	12.80ef	17.38ab	21.30cd	6.67bc	11.83bc	15.57c
V_2T_3	6.97cd	12.03bc	14.73de	13.17def	15.73bcd	19.28ef	5.82c	11.35bc	13.37cd
V_3T_1	7.57cd	14.27b	17.60c	14.30bcd	18.00ab	20.75cde	6.75bc	12.85bc	13.20cd
V_3T_2	7.37cd	11.09bc	14.27de	13.53cde	17.90ab	20.27de	6.40bc	11.83bc	13.77bcd
V_3T_3	6.42d	9.77c	12.90e	11.98f	14.45d	18.08f	6.23bc	10.53c	12.20d
Level of significant	*	*	*	*	*	*	*	*	*
SE (±)	0.26	0.65	0.53	0.26	0.51	0.33	0.48	0.73	0.82
CV (%)	5.92	7.88	5.14	3.29	5.20	2.75	11.71	9.84	9.24

* = Significant at 5 % level of probability, CV=Co-efficient of variations, SE (±) = Standard Error. V_1= Green Finger, V_2= BARI Dherosh-1, V_3= A local variety, T_1= Organic fertilizers (Vermicompost 50%+ Farmyard Manure 50%, @ 10 tons/ha); T_2= Chemical fertilizers (NPK- 80:60:60 kg/ha); T_3= Control, Here, values in the column having a similar letter (s) are statistically identical (Tukey's HSD test at $p<0.05$).

3.5. Leaf breadth

Variability in leaf breadth was observed among the varieties, treatments, and their respective interactions. The Green finger variety exhibited the highest leaf breadth (22.28 cm), whereas the local variety revealed the lowest leaf breadth (19.70 cm; Figure 1e). Regarding the treatment aspect, it was observed that T_1 showed the highest leaf breadth (22.76 cm). On the other hand, the local variety presented the lowest leaf breadth (19.31 cm) at 60 DAS (Figure 2e). In the context of variety and treatment interaction, the highest leaf breadth of 24.30 cm was seen in the V_1T_1 treatment, and the lowest (18.08 cm) was recorded in the V_3T_3 treatment, which was statistically similar to the V_2T_3 treatment (Table 2). A similar observation was found by Arancon et al. (2004) in strawberries and Singh and Chauhan (2009) in French Bean. So organic fertilizers increase leaf breadth, supporting our results.

3.6. Petiole length

The length of the petiole was measured at 30, 45, and 60 days after sowing (DAS). Statistical analysis revealed the presence of considerable variation in petiole length. At 60 days after sowing (DAS), the Green finger variety (V_1) produced the highest petiole length of 17.81 cm, while the local variety (V_3) had the lowest petiole length (13.05 cm; Figure 1f). However, no statistically significant differences were seen throughout the various treatment groups (Figure 2f). In terms of the interaction between variety and treatment, the highest recorded petiole length (19.20 cm) was observed in the V_1T_1 treatment. However, the lowest recorded length (12.20 cm) was observed in the V_3T_3 treatment (Table 2). According to the findings of Joshi et al. (2015), vermicompost has been identified as a highly suitable organic fertilizer that promotes better vegetative growth and development in many plant species.

3.7. Days required for the first flowering

There was no statistically significant variance observed among the varieties of okra and treatments in terms of the timing of first flowering, as indicated in Table 3. A substantial difference was seen in the interaction impact between varieties and treatments. The initial appearance of flowers was recorded in the V_1T_1 treatment at 41.33 days after sowing (DAS). The statistical analysis revealed that this observation was not significantly different from the V_1T_2, V_2T_2, and V_3T_1 treatment combinations. The V_3T_2 treatment exhibited a delayed onset of flowering, with the beginning at 44.67 days after sowing (DAS), as seen in Table 4.

3.8. Pods per plant

A prominent disparity existed in the number of pods per plant. The Green finger variety (V_1) had the highest pod count (30.89), whereas the local variety and BARI Dherosh-1 showed the lowest pod count (Table 3). Regarding the treatment, T_1 demonstrated the highest number of pods (33.00), as opposed to the control treatment revealed the lowest number of pods (25.22; Table 3). The treatment combination marked as V_1T_1 produced the highest count of pods (35.33; Table 4). Simultaneously, treatment V_3T_3 exhibited the lowest pod count (24.00). According to Rameshwar et al. (2006), the application of farmyard manure (FYM) resulted in the highest observed values for variables such as the number of pods per plant, root length, and number of nodules, as compared to the N:P:K treatment. This result is also supported by Singh and Chauhan (2009).

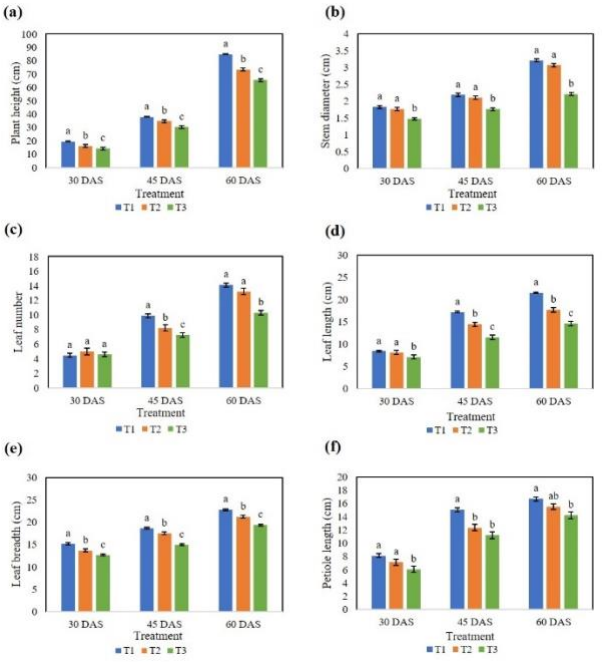

Figure 2: Effect of organic and inorganic fertilizers on vegetative traits of okra at 30, 45, and 60 days after sowing (DAS). (a) plant height (cm); (b) stem diameter (cm); (c) leaf number; (d) leaf length (cm); (e) Leaf breadth (cm); (f) petiole length (cm); T_1: Organic fertilizers (5 t/ha vermicompost and 5 t/ha FYM); T_2: Chemical fertilizers (NPK- 80:60:60 kg/ha); T_3: Control. The values are the averages of three replicates ± SE (standard error). Different letters (a, b, c) show significant differences according to the homogenous subsets of Tukey's HSD test at a 0.05 level of significance.

3.9. Single fruit length

Substantial dissimilarity has been observed in the length of individual fruit. The Green finger variety (V_1) provided the longest fruit length, recording 11.83 cm, whilst the local variety produced its shortest fruit length, measuring 8.62 cm (Table 3). In treatment conditions, organic fertilizers had the largest fruit length (11.50 cm), whereas the control exhibited the shortest fruit length, (8.63 cm; Table 3). Considering the combination effect, Green finger with a mixture of vermicompost @ 5 t/ha + FYM @ 5 t/ha, showed the highest fruit length, averaging 13.38 cm. Meanwhile, the local variety without fertilizer had the lowest fruit length of 7.84 cm (Table 4). In a study conducted by Alam et al. (2019), it was observed that the application of 25 tons per hectare of FYM showed elevated pod length and weight of fresh pod as compared to non-FYM treated plots. A similar observation was reported by Premsekhar and Rajashree (2009).

Table 3. Effects of variety and treatment on reproductive parameters of okra.

Treatments	Days required for first flowering (DAS)	Pod per plant	Single fruit length (cm)	Single fruit diameter (cm)	Single fruit weight (g)	Yield per plot (kg)	Yield per ha (ton)
Variety							
V_1	42.44b	30.89a	11.83a	1.69	13.11a	2.06a	11.09a
V_2	43.22ab	28.67b	10.46b	1.66	11.77b	1.71b	9.21b
V_3	43.89a	28.00b	8.62c	1.66	10.26c	1.44c	7.8c
Level of sig.	*	*	*	NS	*	*	*
SE (±)	0.23	0.46	0.14	0.01	0.14	0.03	0.16
CV (%)	1.13	5.32	3.32	4.54	3.65	4.38	5.87
Nutrients							
T_1	42.56b	33.00a	11.5a	1.81a	12.92a	2.14a	11.58a
T_2	43.11ab	29.33b	10.79b	1.62b	12.33b	1.82b	9.8b
T_3	43.89a	25.22c	8.63c	1.57b	9.89c	1.25c	6.74c
Level of sig.	*	*	*	*	*	*	*
SE (±)	0.23	0.46	0.14	0.01	0.14	0.03	0.16
CV (%)	1.61	4.72	4.16	3.61	3.28	5.28	5.31

* = Significant at 5 % level of probability, CV=Co-efficient of variations, SE (±) = Standard Error. V_1= Green Finger, V_2= BARI Dherosh-1, V_3= A local variety, T_1= Organic fertilizers (Vermicompost 50%+ Farmyard Manure 50%, @ 10 tons/ha); T_2= Chemical fertilizers (NPK- 80:60:60 kg/ha); T_3= Control, Here, values in the column having a similar letter (s) are statistically identical (Tukey's HSD test at $p<0.05$).

Table 4. Interaction effects of variety and treatment on reproductive parameters of okra.

Treatment combination	Days required for first flowering (DAS)	Pod per plant	Single fruit length (cm)	Single fruit diameter (cm)	Single fruit weight (g)	Yield per plot (kg)	Yield per ha (ton)
V_1T_1	41.33c	35.33a	13.38a	1.86a	14.83a	2.62a	14.15a
V_1T_2	42.33bc	30.67bc	12.53ab	1.57d	14.13ab	2.17b	11.70b
V_1T_3	43.67ab	26.67cde	9.57d	1.63cd	10.35de	1.38de	7.45d
V_2T_1	43.67ab	32.33ab	11.87bc	1.82ab	13.02bc	2.11b	11.37b
V_2T_2	42.33bc	28.67bcd	11.02c	1.62cd	12.20c	1.75c	9.45c
V_2T_3	43.67ab	25.00de	8.50de	1.53d	10.11de	1.26ef	6.81de
V_3T_1	42.67abc	31.33ab	9.27d	1.77abc	10.92d	1.71c	9.22c
V_3T_2	44.67a	28.67bcd	8.75de	1.66bcd	10.67d	1.53cd	8.26cd
V_3T_3	44.33ab	24.00e	7.84e	1.55d	9.22e	1.11f	5.98e
Level of sig.	*	*	*	*	*	*	*
SE (±)	0.40	0.79	0.25	0.24	0.03	0.05	0.29
CV (%)	1.61	4.72	4.16	3.61	3.28	5.28	5.31

* = Significant at 5 % level of probability, CV=Co-efficient of variations, SE (±) = Standard Error. V_1= Green Finger, V_2= BARI Dherosh-1, V_3= A local variety, T_1= Organic fertilizers (Vermicompost 50%+ Farmyard Manure 50%, @ 10 tons/ha); T_2= Chemical fertilizers (NPK- 80:60:60 kg/ha); T_3= Control, Here, values in the column having a similar letter (s) are statistically identical (Tukey's HSD test at $p<0.05$).

3.10. Individual fruit diameter

Table 3 indicates that there was no significant variation perceived among the varieties of okra in terms of fruit diameter. The T_1 treatment revealed an enormous fruit diameter, at 1.81 cm, whereas the control treatment had the lowest diameter of 1.57 cm, which was close to the size of the BARI Dherosh-1 variety (Table 3). When examining the various treatment combinations, it was observed that the treatment V_1T_1 exhibited the highest fruit diameter of 1.86 cm, which was similar to the V_2T_1 and V_3T_1. In contrast, V_3T_3 exhibited the lowest fruit diameter (1.55 cm; Table 4). Adhikari and Piya (2020) reported that the fruit diameter of okra was significantly influenced by organic sources of nutrients.

3.11. Individual fruit weight

The weight of individual fruits exhibited variability among okra varieties, treatments, and their combined effects. The Green finger variety showed the maximum fruit weight (13.11 g) and the local variety presented the lowest fruit weight (10.26 g; Table 3). The use of organic treatment resulted in the highest fruit weight (12.92 g) compared to the chemical and control treatments (Table 3). In the context of a combination approach, V_1T_1 showed the highest fruit weight of 14.83 g. Conversely, the local variety with control treatment (V_3T_3), exhibited the lowest fruit weight of 9.22 g (Table 4). Arancon et al. (2004) claimed that the application of vermicompost resulted in substantial enhancements in strawberry growth and yields, with significant increases observed in the number of plant runners (up to 36%) and marketable fruit weights (up to 35%).

3.12. Yield per plot

The Green finger variety provided the largest output per plot of okra (2.06 kg) whereas the local variety produced the lowest yield at 1.44 kg (Table 3). The utilization of organic fertilizers resulted in the highest yield per plot (2.14 kg) compared to the use of inorganic fertilizers and without the use of any fertilization (Table 3). In combination effect, V_1T_1 demonstrated the highest production per plot, at 2.62 kg. However, the local variety without any fertilizer displayed the lowest yield (1.11 kg; Table 4). Yadav and Vijayakumari (2003) found better yield per plot in vermicompost treatment. The growth and yield of garlic on the application of vermicompost and farm yard manure were studied by Suthar (2009). Joshi et al. (2015) found that vermicompost enhances crop yield and protects against destructive pests without affecting the environment.

3.13. Yield per ha

Considerable divergence was observed in yield per ha of okra. The Green finger variety showed the highest production per ha (11.09 tons). In the meantime, the local variety exhibited the lowest yield of 7.8 tons per ha (Table 3). The organic fertilizers generated the highest production per ha of 11.58 tons than the control treatment (Table 3). In interaction effect, the Green finger variety with vermicompost @ 5 t/ha + FYM @ 5 t/ha (V_1T_1) showed the highest yield per ha at 14.15 tons. Inversely, the local variety in the control condition exhibited the lowest yield at 5.98 tons (Table 4). The vermicompost treatment, when combined with FYM, exhibited the highest levels of overall growth and yield. These results of three different varieties of okra align with the previous findings of Kumaran, (2001); Sankhyan et al. (2001); and Wang et al. (2017). As FYM and vermicompost not only act as storehouses of nutrients, these simultaneously improve the physiochemical and biological properties of the soil resulting in more production of crops (Khan et al. 2023). Consequently, it is possible to state that the use of organic fertilizers results in a significant increase in stem diameter, subsequently verifying our research findings.

4. Conclusion

The deliberate use of vermicompost and farmyard manure (FYM) exhibited a notable impact on both the vegetative and reproductive growth of the Green finger cultivar of okra. The findings of the study indicated that the mentioned variety showed a favorable response when subjected to a combination of vermicompost @ 5 t/ha + FYM @ 5 t/ha, as compared to chemical fertilizers and without fertilizer. Based on the empirical evidence presented in this work, it can be inferred that using a combination of vermicompost and FYM holds promise as a viable approach to enhance the fertility of the soil in vegetable cultivation. Particularly, the application of these organic fertilizers exhibits potential benefits in terms of enhancing okra yields. Further research is required in different seasons and different agroecological zones of Bangladesh for better production.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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