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Comparative Evaluation of Growth and Yield Parameters of Different Okra Varieties in Lamjung, Nepal

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This research aimed to evaluate the performance of different okra varieties in Lamjung district, Nepal, to identify high-yielding cultivars suitable for local cultivation.
Study Design: The study used a randomized complete block design (RCBD) with seven okra varieties (treatments) and three replications per treatment, totaling 21 plots.
Place and Duration of Study: The experiment was conducted in Beshishar, Lamjung District, Nepal. Data collection and experimentation were carried out over the growing season of okra.
Methodology: Growth and yield parameters including plant height, number of leaves and primary branches per plant, days to first flowering, number of nodes at first flowering, number of pods per plant, pod length, pod weight, yield per plant, and yield per hectare were measured and recorded from selected plants within each plot. Statistical analysis was done to compare the performance of different varieties.

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Results: Significant variations were observed across the varieties, with F1 Glory and Arka Anamika outperforming others. F1 Glory showed the highest plant height at 106.4 cm and the maximum yield at 9.02 t/ha, followed closely by Arka Anamika with a plant height of 88 cm and a yield of 8.45 t/ha. In contrast, Parvati recorded the lowest plant height at 63.33 cm and yield at 6.08 t/ha. Additionally, F1 Glory had the highest number of leaves (26.60 per plant), primary branches (3.15 per plant), and the longest pod length (14.94 cm), further contributing to its superior yield. The variety also achieved the highest pod weight, averaging 15.85 g per pod, which was significantly higher than S-51's 11.19 g per pod. Arka Anamika, while slightly behind F1 Glory, still showed robust performance with a pod length of 13.94 cm, an average pod weight of 14.49 g, and a similar number of leaves (22.80 per plant). Parvati, on the other hand, consistently underperformed in all agronomic traits, with a pod length of 10.45 cm, a lower number of primary branches (1.74 per plant), and the smallest number of leaves (13.60 per plant).

Conclusion: The findings indicate that varieties viz., F1 Glory and Arka Anamika excelled in yield and growth parameters in Lamjung district. These varieties could enhance local productivity by addressing current challenges in okra cultivation. This study gives valuable insights for selecting suitable okra varieties and enhancing agricultural sustainability and economic outcomes.

Keywords: Okra varieties; growth characteristics; plant height; yield parameters; Lamjung district.

1. INTRODUCTION

Okra *(Abelmoschus esculentus)*, a self-pollinating annual plant, is a well-known vegetable crop that has important agricultural, culinary, and nutritional value [1]. It requires warm temperatures of 20-30 degrees Celsius [2] and has its origin in Ethiopia and Sudan, [1]. It is a versatile vegetable crop due to its various uses of fresh leaves, buds, flowers, pods, stems, and seeds [3] that can be eaten in many ways, viz., boiled, fried, or cooked, and is used in soups, stews, and pickles [4]. It is a nutrient-rich vegetable providing 1.9 g protein (contains both lysine and tryptophan amino acids), 0.2 g fat, 6.4 g carbohydrates, and 1.2 g fiber per 100 g of edible portion, along with essential vitamins and minerals [5,6]). It has antioxidant activity [7] and health benefits such as improved digestive health, potential management of cardiovascular disease, type 2 diabetes, and protective food additive against inflammatory gastric diseases [8-9] & [10]. Furthermore, nearly every part of the plant is covered with unicellular trichomes for protection from pests like leafhoppers [11]. Its seeds are a source of oil used as a coffee substitute which can be pulverized to replace aluminum salts in the process of purifying water [12].

As a result of a growing population and rapid urbanization, vegetable demand is increasing throughout the world but the production potential of vegetable and vegetable seeds of our country is not satisfying. Global okra production is estimated to be around 10,822,249 tons in 2021. India is the leading producer with 6,466,000 tons followed by Nigeria and Mali [13]. The total production of okra in Nepal was 11 metric tons under an area of 9,397 hectares with a productivity of 11.95 t/ha [14]. The main reason for the unsatisfactory yield of okra across the country is the use of low-yielding varieties with poor agronomic traits [15], the absence of location-specific varieties [16], poor seed quality [17], and the use of seeds from previous harvest [15]; therefore, for the identification of best variety that suit existing environmental conditions, researches, and experimental trails are needed in many parts of the country. Moreover, foundation of raising productivity is the use of suitable genotypes with high yield potential and standard traits [18]. The major factors that ultimately determine the overall production of the variety or cultivar of okra vary greatly between genotypes, including fruit number, fruit length, fruit weight, and fruit yield per plant [19].

The purpose of this research was to evaluate the performance of different okra varieties in the Lamjung district, Nepal to identify high-yielding varieties to improve productivity. Because of the current low productivity and challenges faced in okra cultivation in the region, this study aims to address the lack of location-specific varieties and improve. By evaluating growth and yield parameters, the research wants to provide valuable insights and practical recommendations for selecting the most suitable okra varieties.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted in Beshishar, Lamjung District, Nepal, situated at a latitude of 28°48' N and a longitude of 84°28' E, with an altitude of 600 meters above sea level.

2.2 Climatic Condition of the Research Site

Lamjung has a sub-tropical humid climatic condition where temperatures typically range between 9 ℃ and 22 ℃ through the year, but rarely can drop to -3 ℃ or can rise to as high as 29 ℃. The average annual precipitation is about 5961 mm (Source: Weather and Climate- The Global Historical Weather and Climate Data 2023).

2.3 Experimental Detail

2.3.1 Experimental design

The experiment was conducted using a randomized complete block design (RCBD) with seven treatments and three replications, resulting in a total of 21 plots. Each plot had 4 rows with 5 plants per row, totaling 20 plants per plot. From each plot, 5 inner plants were selected as samples.

2.3.2 Experimental materials

The varieties used as treatments in the research are shown in Table 1.

2.3.3 Field Layout

Each plot measured 1.8 meters in length and 1.5 meters in breadth. The spacing between plants was 45 cm, and the spacing between rows was 30 cm. Each plot contains 4 rows with 5 plants per row. The total experimental plot area was 2.7 square meters, with a spacing of 50 cm between treatments and 1 meter between replications. The total area for the research was 145.7 square meters.

2.4 Agronomic Management

Field preparation, layout, manure and fertilizer application, seed treatment, irrigation, weeding, pest management, and harvesting were done according to standard practices [20]. All procedures were implemented to ensure optimal growing conditions and effective management throughout the experiment.

2.5 Observation and Data Recording

Five plants were selected randomly from the inner row of each plot for collection of data. Plots were tagged with A4 paper laminated with plastic that reflects variety. The data regarding the yield and its contributing characters were collected and analyzed with R-Studio software.

2.5.1 Growth parameters

Plant height was recorded on five selected plants from the inner observation area from 40 days after sowing (DAS) and continued at 10-day intervals, with the final average height calculated for each plot. The number of fully opened leaves per plant was counted from selected plants at 10-day intervals starting from 40 DAS, and the mean was determined. Additionally, the total number of primary branches per plant was recorded at the final harvest stage from five selected plants, and their average was calculated.

2.5.2 Reproductive parameters

The number of nodes at which the first flower appeared was recorded by counting five specific plants from each plot, and the average was calculated. Days to first flowering (anthesis) was observed on five randomly selected plants, and the average number of days taken to reach this anthesis was recorded.

2.5.3 Yield and yield parameters

2.5.3.1 No of pods/plant

The number of pods in the selected plants from each plot was recorded. It was calculated by the following formula:

No of pods/plant =

$$\frac{total\ no\ of\ pods\ from\ 5\ sample\ plants}{5}$$ [15]

Table 1. List of varieties used in the research

Treatment Number	Name of Variety	Germination %	Physical purity	Genetic Purity	Producer Company/ Organizations
1.	Arka Anamika	65 %	98%	98%	NARC, Kaski
2	Parvati	65 %	98%	98%	NARC, Kaski
3.	Venus	65%	99%	95%	UPL Ltd, India
4.	S-51	65 %	98%	98%	Mayco Pvt. Ltd, India
5.	F1 Glory	70 %	98 %	98 %	Rizwan Seeds Co. India
6.	Rajrani	65%	98%	98%	Shatabdi Seeds Pvt. Ltd. India
7.	Bhindi-F1	70 %	97%	98%	Prime Seed Company Pvt. Ltd, Kaski

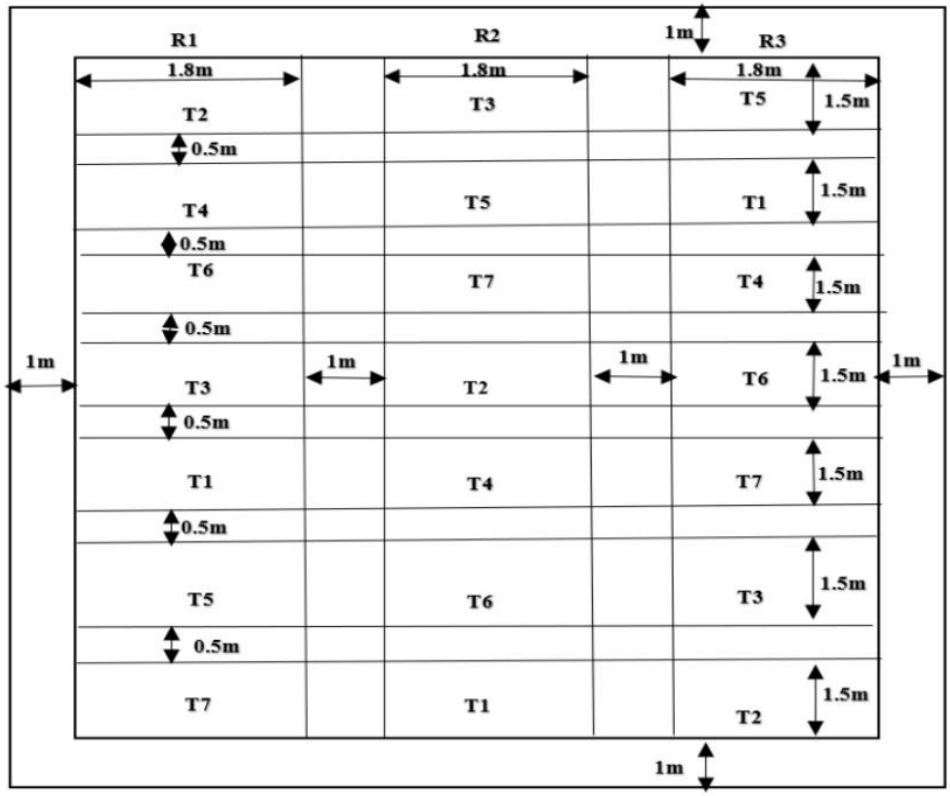

Fig. 1. Layout of field showing spacing and randomization of treatments

2.5.3.2 Pod weight

The weight of pod was measured in gram (g) by using a digital weighing machine. It was calculated by the following formula:

Weight of pod = $\frac{total\ wt.\ of\ pods\ from\ 5\ sample\ plants}{total\ no\ of\ pods\ from\ 5\ sample\ plants}$ [21]

2.5.3.3 Pod length

The length of pods was measured with a measuring scale from the neck of the pod to the bottom of harvested pods from the inner selected plants of each plot and the average was taken in centimeters (cm) [15].

2.5.3.4 Yield per plant (g/plant)

It was calculated about the inner selected plants. The total yield from inner selected plants divided by the number of selected plants at the final harvest gave the average yield/plant.

2.5.3.5 Yield

Pod yield/hectare was calculated in metric tons (MT). It was calculated by multiplying the

average yield per plant by the number of plants accommodated in one hectare of land as follows:

$$\text{Yield (mt/ha)} = \frac{pod\ yield/plant \times 10000\,m2}{spacing(RR*PP)} \quad [21]$$

3. RESULTS AND DISCUSSION

Generally, all okra varieties showed significant degree of variation in terms of growth and yield parameters, including plant height, no of leaves per plant, no of primary branches per plant, pod length, pod weight, no of pods per plant, days to first flowering. The collected data were analyzed with R-Studio software.

3.1 Comparative Evaluation of Growth Parameters of Different Varieties

3.1.1 Plant height

The results showed there was a significant difference in plant height at all growth stages as shown in Table 2. At 40 DAS, Parvati variety recorded the highest mean significant height of 20.55 cm followed by Arka Anamika (19.18 cm) while Bhindi-F1 recorded the lowest mean height of 14.24 cm. Furthermore, there was no significant difference between the varieties viz., Arka Anamika (19.18 cm), F1 Glory (20.47 cm), and Parvati (20.55 cm). At 50 DAS, F1 Glory recorded the highest mean significant height of 55.77 cm followed by Bhindi-F1 (49.00 cm) while the S-51 variety recorded the lowest mean height of 28.08 cm. Additionally, Arka Anamika (38.9 cm) and Parvati (42.03 cm) were statistically similar with the mean values of 38.97 cm and 42.03 cm respectively. A similar pattern of growth was also observed at 60 and 70 DAS where there was a significant increase in plant height. The highest mean plant height was recorded by the F1 Glory variety, with mean values of 84.80 cm at 60 days after sowing (DAS) and 106.40 cm at 70 DAS. Following this, the Arka Anamika variety had mean heights of 74.67 cm at 60 DAS and 88 cm at 70 DAS. In contrast, the lowest mean heights were observed in the S-51 variety, which measured 48.26 cm at 60 DAS, and the Parvati variety, which measured 63.33 cm at 70 DAS.

Similar plant height variation was also observed by Biswas et al., & Dahal et al [15,18] and according to them, these variations were due to differences in nutrient uptake, fertilizer management, climatic factors, and plant density. Furthermore, the results also showed by D. K. Mehata et al [19] but with a larger mean height value than our treatments. This may be due to the differences in environmental conditions of Lamjung district as it experiences more frequent rainfall and lower average temperature than those of terai region resulting in a slower growth rate over time.

3.1.2 Number of leaves per plant

The number of leaves per plant was recorded at 40, 50, 60, and 70 days after sowing, which ranged between 7 to 26.6 leaves (Table 3). At 40 DAS, the highest mean number of leaves was observed on F1 Glory (13.13) followed by Arka anamika (11.37) whereas the lowest mean number of leaves was observed in Parvati (7.00) which was statistically similar to Bhindi-F1 (8.61) and S-51 (8.60). At 50 DAS, the highest mean number of leaves was observed in F1 Glory (17.33) followed by Arka Anamika (14.06) whereas the lowest mean number of leaves was observed in Rajrani (8.00) which was statistically similar to Parvati (9.20). A similar pattern of results was observed at 60 DAS and 70 DAS, where F1 Glory had the highest number of leaves with mean values of 22.53 and 26.60 at 60 DAS and 70 DAS respectively followed by Arka Anamika with the mean value of 18.20 and 22.80 at 60 DAS and 70 DAS whereas lowest mean number of leaves was observed in Parvati with the mean value of 10.73 and 13.60 at 60 DAS and 70 DAS respectively.

Significant differences were observed in the mean number of leaves per plant of the different varieties. According to Dahal et al, this might be because of factors including soil fertility, growing season, and variety [15]. A similar result was also observed in different varieties of okra by Dimkpa et al. [22] Furthermore, Variations in the number of branches, plant height, and each hybrid's capacity for photosynthesis could all be contributing factors to the difference in the number of leaves per plant [22].

3.1.3 Number of primary branches per plant

The maximum number of primary branches was observed in Venus (3.90) followed by F1 Glory (3.15), whereas the minimum numbers of primary branches were observed in Bhindi-F1 (1.74). The variations in the varieties could be due to their genetic makeup which might have an impact on the variations in growth parameters [23]. Moreover, the variance in plant height and each hybrid's capacity for photosynthetic energy may

be the cause of this variety in the number of branches per plant. The current study's outcome is consistent with the research conducted by Nwangburuka et al & Reddy et al [24,25].

3.2 Comparative Evaluation of Reproductive Parameters of Different Varieties

3.2.1 Days to first flowering

Days to anthesis were found to differ significantly throughout varieties (Table 4) which ranges from 56.73 to 64.40. The first flower opening was recorded in Parvati at 56.73 days, which was statistically identical to Arka Anamika (56.13 days) while the late first opening of a flower was recorded in F1 Glory at 64.40 days which was statistically identical to Bhindi-F1 (60.13 days) and Rajrani (60.53 days).

According to Biswas A. et al., the earliest flowering was observed in the BARI Dherosh 1 variety at 41.33 days, while the Kashi Kranti variety flowered at 42.33 days [15]. In comparison to these reports, the number of days

Table 2. Mean of plant height at various stages of different okra varieties tested in Lamjung, Nepal (2023)

Treatment	Plant height (cm)			
	40 DAS	50 DAS	60 DAS	70 DAS
Arka Anamika	19.18^{a}	38.97^{bc}	74.67^{ab}	88.00^{bc}
Parvati	20.55^{a}	42.03^{bc}	54.47^{cd}	63.33^{d}
Venus	17.89^{ab}	32.15^{cd}	58.71^{cd}	70.06^{d}
S-51	16.57^{ab}	28.08^{d}	48.26^{d}	73.60^{cd}
F1 Glory	20.47^{a}	55.77^{a}	84.80^{a}	106.40^{a}
Rajrani	16.23^{ab}	35.98^{cd}	52.83^{cd}	78.53^{bcd}
Bhindi-F1	14.24^{b}	49.00^{ab}	74.67^{bc}	93.80^{ab}
LSD (0.05)	4.02	9.95	12.20	15.08
SEm (±)	0.49	1.22	1.49	1.85
F-probability	<0.05	<0.001	<0.001	<0.001
CV	12.64	13.88	10.95	10.28
Grand mean	17.87	40.28	62.65	82.39

*Means followed by common letter(s) within column are non-significantly different based on DMRT at P=0.05; LSD, Least Significant Difference; SEM, Standard Error of Mean; CV, Coefficient of Variation; DAS, Days After Sowing; NS, Non-Significant, * significant at 5% level of significance, ** significant at 1% level of significance, *** significant at 0.1% level of significance*

Table 3. Mean of number of leaves at various stages of different okra varieties tested in Lamjung, Nepal (2023)

Treatment	No of leaves per plant			
	40 DAS	50 DAS	60 DAS	70 DAS
Arka-anamika	11.37^{ab}	14.06^{b}	18.20^{b}	22.80^{b}
Parvati	7.00^{c}	9.20^{d}	10.73^{c}	13.60^{e}
Venus	9.40^{bc}	13.13^{bc}	15.26^{b}	18.06^{d}
S-51	8.60^{c}	12.66^{bc}	15.13^{b}	20.26^{c}
Glory-F1	13.13^{a}	17.33^{a}	22.53^{a}	26.60^{a}
Rajrani	7.40^{c}	8.00^{d}	11.53^{c}	16.66^{d}
Bhindi-F1	8.61^{c}	11.53^{c}	18.06^{c}	23.67^{b}
LSD (0.05)	2.61	1.85	3.22	1.62
SEm (±)	0.32	0.23	0.39	0.19
F-probability	<0.01	<0.001	<0.001	<0.001
CV	15.69	8.46	11.38	4.50
Grand mean	9.36	12.28	15.92	20.24

*Means followed by common letter(s) within column are non-significantly different based on DMRT at P=0.05; LSD, Least Significant Difference; SEM, Standard Error of Mean; CV, Coefficient of Variation; DAS, Days After Sowing; NS, Non-Significant, * significant at 5% level of significance, ** significant at 1% level of significance, *** significant at 0.1% level of significance*

Fig. 2. Number of primary branches in different okra varieties

required to first flowering was found to be greater than the present findings. This variation could be due to differences in environmental factors such as rainfall, temperature, and light intensity and duration. Additionally, the genetic makeup that results in a shorter vegetative phase, leading to early flowering, may also contribute to the variation. Similar findings have been reported by Wakhande et al [26].

3.2.2 Nodes at first flowering

Node at first flowering varied significantly among the varieties (Table 4). The variety Arka Anamika produced flowers at 2.76 nodes (lowest number of nodes) and S-51 produced flowers at 3.90 nodes which is the highest number of nodes.

3.3 Comparative Evaluation of Yield and Yield Parameters of Different Varieties

3.3.1 Number of pods per plant

The numbers of pods per plant differ significantly among the varieties as shown in Table 4. The highest number of pods per plant was recorded in the variety F1 Glory (12.37) followed by Arka Anamika (10.83). On other side lowest number of pods per plant was recorded in the variety Parvati (7.36). Furthermore, Venus (8.60), Rajrani (7.63) and S-51 (7.53) were statistically identical. This demonstrates that a rise in plant height, reduced intermodal length, and branch count also led to an increase in fruit production. The present study seems to agree with the results of Mehata et al & Rahman et al [19,27] According to Dahal et al, this variation could be due to differences in genetic makeup and environmental effects [15].

3.3.2 Pod length (cm)

Pod length varies significantly among the varieties as shown in Table 4. The longest length of the pod was recorded in F1 Glory (14.94 cm) followed by Venus (13.94 cm) whereas the shortest length of the pod was recorded in S-51 (9.59 cm). Also, varieties Rajrani (9.85 cm), S-51 (9.59 cm), and Parvati (10.45 cm) were statistically identical. The current study's findings are consistent with those of Biswas A. et al., who determined that the greatest pod length measured 13.80 cm and the shortest was 9.13 cm. This variation in pod length may be because of differences in genetic makeup [28].

3.3.3 Weight per pod (gm)

The weight of the pod varied significantly among the varieties as shown in Table 4. The maximum weight per pod was recorded in F1 Glory (15.85 g) followed by Arka Anamika (14.49 g) whereas the minimum weight per pod was recorded in S-51 (11.19 g). This variation may result from variations in the hybrids' vegetative growth, which affects photosynthesis and, ultimately, fruit weight (Dhall, Arora, Dhillon, & Bansal, 2003). The present findings are in agreement with the results of Dahal et al. who determined that the greatest pod weight measured 15.90 gm and the lowest was 9.80 gm [15].

Table 4. Mean of reproductive and yield parameters of different okra varieties in Lamjung, Nepal (2023)

Treatment	No of pods per plant	pod length (cm)	weight / pod(gm)	Yield per plant (g)	Yield (t/ha)	Days to first flowering	Nodes to first flowering
Arka Anamika	10.83^{b}	12.00^{c}	14.49^{ab}	114.14^{ab}	8.45^{ab}	56.13^{bc}	2.76^{d}
Parvati	7.36^{d}	10.45^{d}	12.13^{bc}	82.15^{d}	6.08^{d}	51.73^{c}	3.20^{bcd}
Venus	8.60^{cd}	13.94^{b}	12.18^{bc}	90.94^{cd}	6.74^{cd}	58.57^{b}	3.60^{ab}
S-51	7.53^{cd}	9.59^{d}	11.19^{c}	85.97^{cd}	6.36^{cd}	55.73^{bc}	3.90^{a}
F1 Glory	12.37^{a}	14.94^{a}	15.85^{a}	121.77^{a}	9.02^{a}	64.40^{a}	3.46^{abc}
Rajrani	7.63^{cd}	9.85^{d}	13.44^{abc}	92.13^{cd}	6.82^{cd}	60.53^{ab}	3.03^{cd}
Bhindi-F_1	9.03^{c}	11.73^{c}	12.64^{bc}	99.67^{bc}	7.38^{bc}	60.13^{ab}	3.36^{bc}
LSD (0.05)	1.41	1.15	2.72	14.98	1.11	5.09	0.46
SEm (±)	0.17	0.14	0.33	1.84	0.14	0.63	0.06
F-test	<0.001	<0.001	<0.05	<0.001	<0.01	<0.01	<0.01
CV (%)	8.78	5.55	11.63	8.59	8.59	4.92	7.81
Grand mean	9.05	11.68	13.14	98.11	7.27	58.18	3.33

*Means followed by common letter(s) within column are non-significantly different based on DMRT at P=0.05; LSD, Least Significant Difference; SEM, Standard Error of Mean; CV, Coefficient of Variation; DAS, Days After Sowing; NS, Non-Significant, * significant at 5% level of significance, ** significant at 1% level of significance, *** significant at 0.1% level of significance*

3.3.4 Yield per plant (g/plant)

Yield per plant varied significantly among the varieties as shown in Table 4. The highest yield per plant was recorded in F1 Glory (121.11 g) followed by Arka Anamika (114.14 g) whereas the lowest yield per plant was recorded in Parvati (82.15 g). Similarly, Rajrani (92.13 g), Venus (90.94 g), and S-51 (85.97 g) were statistically identical. Biswas A. et al and Dahal et al. reported higher yield per plant than the results of the present study [15,18]. Increased branch count, fruit weight, and fruit yield per plant are all positively correlated [29]. Moreover, this may be because of differences in genetic makeup, management practices, and shorter harvesting periods. However, the observed results are within the range of findings reported by Yadav et al. [30].

3.3.5 Yield (t/ha)

The highest yield per hectare was recorded in F1 Glory (9.02 t/ha) followed by Arka Anamika (8.45 t/ha) whereas the lowest yield per hectare was recorded in Parvati (6.08 t/ha). The observed outcomes coincide with the conclusion of Biswas A. et al., Dahal et al., & Rahman K. et al [15,18,28]. According to Dahal et al., these variations in yield in varieties are due to genetic factors, and their interactions with environmental conditions, as all these varieties are tested under the same soil, management, and similar agro-climatic conditions [15].

4. CONCLUSION

This study shows that different okra varieties vary significantly in growth and yield. F1 Glory had the best results for pod number, length, weight, and overall yield, while Parvati had the lowest. These differences suggest that genetics play a key role in okra productivity. The study highlights the advantage of choosing high-yielding varieties like F1 Glory to enhance production. However, the research was limited to one growing season and location. Future studies should test multiple locations and seasons to confirm these results and investigate the genetic factors behind the differences.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The author(s) affirm that no generative AI technologies, including Large Language Models or text-to-image generators, were utilized in the writing or editing of this manuscript.

COMPETING INTERESTS

The authors have declared that no competing interests exist.

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