Assessment of different okra (*Abelmoschus esculentus* L.) varieties for yield and biomass production

Abstract

In a field experiment conducted at G. P. Koirala College of Agriculture and Research Center, Morang, Nepal, spanning from April to August 2022, the objective was to evaluate the yield and biomass production of different okra (*Abelmoschus esculentus* L.) varieties. Employing a randomized complete block design with three replications, the study included varieties such as Arka Anamika, Chandani, Chiranjeevi F1, F1 Glory, Gunjan, JK1666, OH-940, Punjab Selection, R35 Selection, and Swastik-2. Results revealed significant variability among the varieties, with F1 Glory (0.91 Kg/m^2) and Punjab Selection (0.96 Kg/m^2) emerging as top performers in average yield per m^2. Conversely, Arka Anamika, Gunjan, and JK1666 exhibited the lowest yields. Notably, Punjab Selection (4.17 Kg/m^2), OH-940 (4.28 Kg/m^2), and Swastik-2 (3.86 Kg/m^2) showcased the highest fresh biomass, while Gunjan had the lowest biomass. F1 Glory demonstrated the highest harvest index (1.14), followed by Chandani and Punjab Selection (both 0.88). These findings emphasize the substantial influence of varietal selection on okra productivity, highlighting the potential of Punjab Selection and F1 Glory for further exploration in vegetable cultivation and biomass production. The study provides valuable insights for optimizing okra cultivation strategies in Nepal and similar agroecological contexts.

Keywords

Abelmoschus esculentus, Okra biomass, Fresh plant weight, Okra performance, Okra Varieties

Introduction

The fibrous pods of okra (*Abelmoschus esculentus* L.), commonly referred to as "lady's finger," make it one of the most significant and nutrient-dense vegetables widely cultivated in tropical and warm temperate parts of the world (Jonah et al., 2019). Biomass is the leftover residue of agricultural plants like roots, shoots, and stems (Freidenreich et al., 2022;Lee et al., 2020). Biomass is classified into four types; they are woody biomass (it consists of wood plants and trees), non-woody biomass (plants parts like stems, roots, and leaves), process waste biomass (waste from various typed of agroindustry), and processed fuel biomass (producer gas, charcoal, etc.) (Verma et al., 2017). The biomass of the plant is determined by weighing the overall part of the plant individually and the root and shoot separately of an individual plant on the same day (Brocks & Bareth, 2018; Nath et al., 2021). Biomass can be highly obtained from the area where the leguminous crop is planted in the last planting season (Maclaren et al., 2019). A measure of energy produced from green biomass technology is the most effective way to decrease the emission of greenhouse gasses to meet the increasing energy demand and to reduce the problem of global warming (Antar et al., 2021).

Okra is geographically African in origin which falls under the Malvaceae family and is considered a rich source of vitamins, carbohydrate minerals, proteins, and unsaturated fats (Sousa et al., 2020). It is an annual warm-season plant grown under a pH of 5 to 8, mainly for pods (Moosavi et al., 2018). Further, biomass production in okra is highly affected by the various constituents of soil, as these components are directly related to the plant's growth. The production of the biomass of okra varies with the application of fertilizers during cultivation. Higher integration of nitrogenous fertilizer results in higher biomass production as it increases the composition of dry matter and vice versa. Maximum yield of pods and biomass can be obtained through the integrated application of fertilizers than recommended chemical fertilizers (Jonah & Kwaga, 2019). The biomass of okra can be used to synthesize fibers as it is biodegradable and eco-friendly compared to synthetic fibers (Gupta et al., 2021; Singha & Guleria, 2015; Verma et al., 2017). As it is eco-friendly and solves the problems that arise from synthetic fibers, natural textile fibers are highly popular and have huge demand (Gupta et al., 2021; Singha & Guleria, 2015). Lignocellulosic fibers can be obtained from the stem of okra through the process known as retting, where fibers are separated from cementing and gummy components of okra. About 70% of α-cellulose fibers are present in biomass (stem), whose quality is similar to that of jute and can be used for the production of nets, various types of fabrics, carpets, etc. (Gupta et al., 2021). Second-generation fuels can be obtained from okra which helps to decrease dependence on the nonrenewable source or can be used for animal feed (Lee et al., 2020; Vadenbo et al., 2017). Cellulose in okra can be used as an adsorbent for wastewater treatment. Also, it can remove various types of ions and metals present in an aqueous solution. The biomass of okra is composed of hemicellulose (20 to 40 %), cellulose (55 to 65%), and lignin (15 to 25%). It consists of fibers obtained from stem parts (Singha & Guleria, 2015). Dried biomass is converted into powder form for a bed dryer. For the production of bioenergy, Biomass is completely dried before cofiring for the improvement of

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the quality of bioenergy (Verma et al., 2017). Bio flocculants produced from the biomass of okra are a must-suitable and eco-friendly alternative to chemical flocculants (Lee et al., 2018).

Biomass production emerges as a versatile solution to tackle diverse energy-related challenges, facilitating the generation of various types of energy. Despite its inherent benefits after production, the cultivation phase introduces challenges affecting arable land usage, competition with food and fiber crops, uneven soil distribution, nutrient depletion, weed proliferation, environmental impacts, and farmers' predominant focus on marketable pods. Unfortunately, the potential utilization of leftover plant biomass is often overlooked. This study uniquely centers on the exclusive assessment of biomass production and yield in different okra varieties. Given the limited existing research on okra varieties that simultaneously yield the highest biomass and yield, there exists a notable gap in knowledge on this topic. To bridge this gap and address challenges encountered during cultivation, including those related to environmental factors and farmers' practices, the research places a specific emphasis on evaluating ten okra varieties sourced from both domestic and foreign origins. This research aims to contribute valuable knowledge to an underexplored area, shedding light on okra varieties that can potentially maximize both yield and biomass production.

Materials and Methods

Site description

The experiment was conducted in the research field at G. P. Koirala College of Agriculture and Research Center located at Sundarharaicha, Morang, Nepal, to evaluate the yield and biomass of different okra varieties from April 2022 to August 2022. The geographical coordinates of this location are approximately 26^0 40' 49.3" North latitude and 87^0 21' 16.1" East longitude, and it sits at an elevation of 150 meters above sea level. The climate in this region is classified as tropical, characterized by an average annual temperature ranging from 25°C to 35°C. The soil characteristics of the experimental site were analyzed in qualitative measures with the help of a soil test kit box (Table 1).

Table 1: Soil characteristics of the experimental site

S. N.	Soil constituents	Properties
1	Soil pH	6.5
2	Soil texture	Silty loam
3	Nitrogen	Medium
4	Potassium	Medium
5	Phosphorus	Low
6	Surface soil wetness	0.648
7	Profile soil moisture	0.606
8	Root zone soil moisture	0.628

Meteorological data

The climate of the experimental area is tropical, with an average annual temperature ranging between 25 to 35 ˚C. The average maximum temperature was 33.46 ˚C, and the minimum temperature was 22.86 ˚C. The total precipitation during the experimental period amounted to 1254.20 mm. The meteorological data during the whole experimental period is dipected in Figure 1.

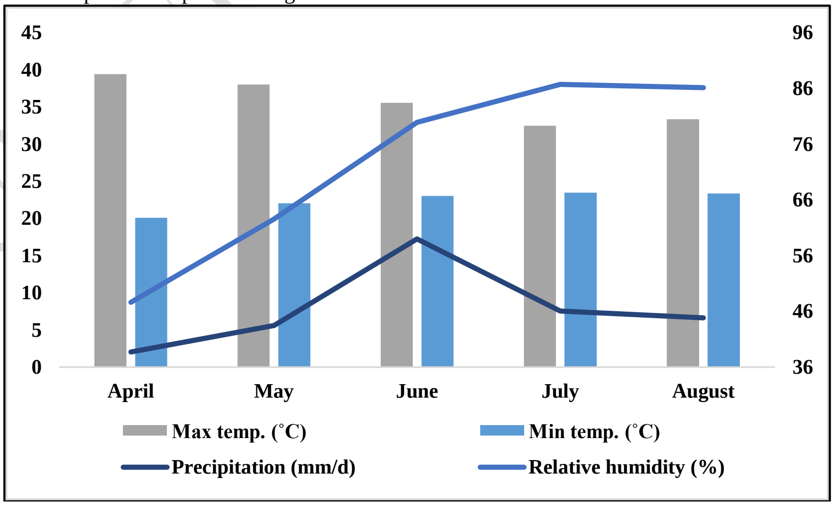

Figure 1. Observational meteorological data throughout the growing period of okra in Gothgaun, Morang.

Cultural practices

The field experiment followed a Randomized Complete Block Design (RCBD) and involved ten okra varieties with three replications. The ten different okra varieties in the experiment were Arka Anamika, Chandani, Chiranjeevi F1, F1 Glory, Gunjan, JK 1666, OH-940, Punjab Selection, R35 Selection, and Swastik-2. Each individual plot covered an area of nine square meters (3m x 3m), resulting in a total experimental area of 270 m^2. In each plot, there were 40 plants with a spacing of 0.6 m between rows and 0.35 m between individual plants. Fertilizer was applied at a rate of 120:60:60 kg NPK per hectare, and FYM was applied at a rate of 25 t/ha. The total amount of phosphorus (P) and potassium (K), as well as half of the nitrogen (N) fertilizer, were applied at the time of sowing. The remaining nitrogen doses were split into two applications at 22 and 40 days after sowing (DAS). Weeding was performed manually two times at 20 and 42 DAS. Irrigation was carried out in every two days in response to the soil moisture content.

Data collection

The data collection involved randomly selecting 12 plants from each plot, and data were collected from the first harvest to the last harvest. Harvesting was conducted based on maturity criteria, where okra pods were harvested when they reached a specific size of 12 cm or exhibited a bright green, fleshy appearance according to standard agricultural practices. Yield data (kg/m^2) was recorded at weekly intervals throughout the growth period. Additionally, fresh biomass data, encompassing stem, shoots, roots, and leaves, were collected at the end of the plant's growth period in August. The yield per m^2 was calculated by aggregating individual plant yields within each plot and then normalizing it to the plot area.

Statistical analysis

The obtained data on various parameters was subjected to statistical analysis using Rstudio (4.2.2 version). The significance of the results was assessed through an analysis of variance (ANOVA). Data entry was performed using MS Excel (2019), and the same software was utilized to create graphs and bar charts for the parameters under investigation. To compare the means of various parameters, Duncan's Multiple Range Test (DMRT) was employed, with a significance level of 5% (Gomez & Gomez, 1984).

Results and Discussion

Yield of different okra varieties

The experimental findings underscored the substantial variability in okra yield per m^2 across diverse varieties at distinct days after sowing (DAS), as detailed in Table 1. Notably, the overall mean at 45 DAS stood at 0.09 kg/m^2, exhibiting a subsequent progressive increase, peaking at 1.19 kg/m^2 by 75 DAS before exhibiting a decline. Chandani (1.13 Kg), Punjab selection (1.13 Kg), and Swastik-2 (1.11 Kg) manifested the highest yields per m^2, succeeded by F1 Glory (0.84 Kg) and OH-940 (0.82 Kg). In contrast, Gunjan and JK 1666 displayed the lowest yields (0.20 Kg/m^2). Statistically, the observed variations in each DAS were significant. These findings accentuate the temporal dynamics and significant varietal influences on okra yield, providing valuable insights for agronomic optimization and varietal selection. These findings indicate the dynamic growth patterns in okra crop output over time.

Comment [DM3]: correct the table Number Table 2

Table 1: Yield per m^2 of different varieties of okra on various days after sowing

Comment [DM4]: Table 2

Varieties	45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	Average
Arka Anamika	0.04^{de}	0.36^{d}	0.82^{c}	0.58^{cde}	0.45^{bcd}	0.45^{d}
Chandani	0.09^{bcd}	0.53^{cd}	1.17^{bc}	1.12^{ab}	1.13^{a}	0.80^{ab}
Chiranjeevi F1	0.01^{e}	0.56^{bcd}	0.97^{bc}	0.72^{bcde}	0.33^{cd}	0.52^{cd}
F1 Glory	0.12^{b}	0.92^{ab}	1.66^{a}	1.03^{ab}	0.84^{ab}	0.91^{a}
Gunjan	0.20^{a}	0.64^{abcd}	1.00^{bc}	0.39^{e}	0.20^{d}	0.49^{cd}
JK 1666	0.09^{bcd}	0.76^{abc}	1.15^{bc}	0.55^{de}	0.20^{d}	0.55^{bcd}
OH-940	0.11^{bc}	0.69^{abcd}	1.32^{ab}	0.96^{abcd}	0.82^{ab}	0.78^{ab}
Punjab Selection	0.05^{cde}	0.97^{a}	1.32^{ab}	1.31^{a}	1.13^{a}	0.96^{a}
R35 Selection	0.11^{bc}	0.57^{bcd}	1.24^{abc}	0.99^{abc}	0.72^{abc}	0.73^{abc}
Swastik-2	0.09^{bcd}	0.57^{bcd}	1.30^{ab}	1.11^{ab}	1.11^{a}	0.84^{a}
Mean	0.09	0.66	1.19	0.88	0.69	0.70
SEM±	0.010	0.047	0.055	0.064	0.076	0.039
CV (%)	32.54	30.00	20.18	25.83	35.46	19.66
LSD	0.05	0.34	0.41	0.39	0.42	0.23
F-Test	***	*	*	**	***	**

*Significant at 5% level of significance, **Significant at 1% level of significance, ***Significant at 0.1% level of significance, CV: Coefficient of variance, LSD: Least Significant Difference, SEM: Standard Error of Mean

Fresh biomass and harvest index of different okra varieties

Table 3 illustrates the fresh biomass across various okra varieties. OH-940 and Punjab Selection exhibited the highest average fresh biomass at 4.28 and 4.17 Kg/m2, respectively, which is statistically comparable to Swastik-2 (3.86 Kg) and Chiranjeevi F1 (3.50 Kg). In contrast, Gunjan recorded the lowest biomass at 1.63 Kg. The mean fresh biomass per square meter was calculated as 3.07 Kg, yielding highly significant results at the 0.1% level. This data underscores the variability in fresh biomass among okra varieties, emphasizing the importance of varietal selection in optimizing production outcomes. Furthermore, the investigation revealed noteworthy variability in the harvest index across various research-utilized varieties, as illustrated in Table 3. Variety F1 Glory exhibited the highest harvest index (1.14), followed by Chandani and Punjab Selection with indices of 0.88. Conversely, the lowest harvest index (0.47) was noted in variety Chiranjeevi F1. The statistical significance of these results was established at a 5% level of significance.

Table 3: Fresh biomass and harvest index of different varieties of okra

Variety	Fresh biomass (Kg/m^2)	Harvest index (HI)
Arka Anamika	2.01^{e}	0.55^{bc}
Chandani	3.27^{cd}	0.88^{ab}
Chiranjeevi F1	3.50^{bc}	0.47^{c}
F1 Glory	2.84^{d}	1.14^{a}
Gunjan	1.63^{e}	0.72^{bc}
JK 1666	1.93^{e}	0.79^{abc}
OH-940	4.28^{a}	0.68^{bc}
Punjab Selection	4.17^{a}	0.88^{ab}
R35 Selection	3.17^{cd}	0.78^{abc}
Swastik-2	3.86^{ab}	0.81^{abc}
Mean	3.07	0.77
SEM	0.173	0.043
CV (%)	10.26	24.24
LSD	0.54	0.32
F-Test	***	*

*Significant at 5% level of significance, **Significant at 1% level of significance, ***Significant at 0.1% level of significance, CV: Coefficient of variance, LSD: Least Significant Difference, SEM: Standard Error of Mean

The results revealed the significant variation in yield and biomass production among distinct okra varieties used in the research. The study revealed notable yield disparities among varieties, with results ranging from 0.45 to 0.91 Kg/m^2. In contrast, Biswas et al. (2016) observed a wider range of 0.57 to 1.4 Kg/m^2 in fruit yield, surpassing our findings. Possible factors contributing to this variation may include differences in cultivation practices, environmental conditions, or genetic factors, highlighting the multifaceted nature of yield outcomes in agricultural studies. Similarly, according to Bulo et al. (2019), the highest fruit yield per plant was 0.212 Kg and 0.202 Kg. This result seems to align with the yield given by Punjab selection (0.217 kg) and F1 Glory.Sibsankar et al. (2012) reported that fruit yield per plant ranges from 0.2562 to 0.2744 kg. The presented result seems to be highly varied from the result obtained from the reported experiment. This can probably be due to the differences in genotype or management practices or climatic factors. According to Zareen et al. (2017), the highest pod yield value was 0.99 Kg/m^2 that is similar to our findings given by Punjab Selection 0.96 Kg/m^2. Imoloame & Usman (2018) reported that okra yields varied from 0.185 to 1.812 Kg/m^2. This result seems intensively low from the result obtained in our study. Disparities in agricultural yield might result from variances in soil quality, agronomic practices, or regional weather variables. According to Sharma & Singh(2023), the study revealed that the greatest biomass yield occurred in treatment T1, employing automatic drip irrigation with 100% soil field capacity, yielded 7.2 tons/ha (0.72 Kg/m^2). This outcome appears notably lower than OH-940, it reported highest yield of 4.28 Kg/m^2, suggesting potential factors such as robust growth conditions or genetic influences contributing to OH-940's superior fresh plant weight. The disparity underscores the complex interplay of environmental and genetic factors influencing biomass production, warranting further investigation into optimizing growth conditions and understanding genetic contributors to enhance yields. Likewise, the statistical similarity with Punjab selection (4.17 Kg) and OH-940 (4.28 Kg) suggests consistent performance. Gunjan's lower weight (1.63 Kg/m^2) may result from environmental stress or genetic traits influencing reduced growth. Statistically, Gunjan, Arka Anamika and JK1666 exhibited comparable weightsimplying similar genetic potential or adaptation to common growing conditions. Systematically,Attarde et al. (2012) reported a fresh biomass ranging from 51.5 to 72.4g. Our research yielded significantly higher results, potentially attributed to variations in fertilizer doses or differences in the methodology procedures. Additionally, discrepancies may arise from environmental factors such as soil quality, climate, and cultivation practices, influencing plant growth and overall productivity. Moreover, genetic variations among okra varieties utilized in the studies could contribute to the observed differences in fresh plant weights.

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Conclusion

In conclusion, among the ten examined okra varieties, Punjab selectiondisplayed superior performance, boasting the highest average fresh biomass and overall yield. Conversely, Arka Anamika, Gunjan, and JK1666 exhibited lower biomass, with Arka Anamika producing the least yield. This highlights the substantial impact of varietal selection on okra productivity. Future research should investigate specific traits contributing to high yields, guiding farmers toward optimal cultivar choices. Exploring agronomic practices and environmental factors affecting yield variations could further enhance overall okra production. These findings offer crucial insights for sustainable agriculture, emphasizing the importance of tailored variety selection. Consequently, based on these parameters, Punjab selection and F1 Glory emerge as promising varieties, recommended for further evaluation and utilization in vegetable cultivation and biomass production.

Ethics committee approval

The authors approves the ethics commitee.

Data availability

Data will be made availabale on request.

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