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Performance Evaluation of Different Varieties of Okra (*Abelmoschus esculentus* L.) in Pyuthan District, Nepal

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Abstract Yield analysis is an effective way to understand the overall performance of the different varieties of okra. For this, an experiment was conducted to evaluate the performance of different varieties of okra in the Pyuthan district within the vegetable zone of PMAMP Pyuthan from 29 March to 15 July 2023. An experiment was conducted during the summer season under open field conditions to assess the varietal performance of different okra genotypes. The experimental plot was laid out in a single factorial randomized complete block design (RCBD) with four replications. The experiment comprised five treatments, i.e., Arka Anamika, Rukmani, Raja F1, Special-45, and Arzine hybrid). To evaluate the performance of different varieties, morphological parameter, and yield parameter data were collected at separate time intervals, and further analysis was done using GenStat software. The experiment illustrates that the average mean yield of the five varieties was 65.75 g per plant. Overall, it was further revealed that the Rukmani varieties give the highest average yield (79.50 g), followed by Arka Anamika (76.25 g). The lowest yield was recorded in Raja F1 and Special-45 (52 g). Similarly, other parameters were also analyzed simultaneously to check the yield attributing factor, which revealed that plant average maximum height was observed in Rukmani (29.44 cm) at all growth stages, followed by Arzine (27.59 cm), Arka Anamika (26.21 cm), Special-45 (22.28 cm), and Raja F1 (20.74 cm). Moreover, the number of primary branches was highest in Arzine (3) followed by Rukmani (2), Special-45(2), and Arka Anamika (2). Furthermore, the number of pods per plant was most significant in the Rukmani variety (6) and Arka Anamika (6). The study showed that the Arka Anamika was found in pod diameter (5.83 cm) among the other four varieties where the maximum pod length was recorded in the Rukmani variety (14.08 cm) followed by Arka Anamika. The pod weight was highest in Rukmani (14.50 g) and Arzine (14.50 g). Data revealed from the experiment showed that the Rukmani variety gave more yield per plant,and showed higher pod weight, pod per plant which are slight differences from Arka Anamika. From the field research, it can be concluded that Rukmani and Arka Anamika is a good varieties in terms of yield performance and more economical to the farmers who have growing okra in Pyuthan, Nepal.
Keywords Okra (*Abelmoschus esculentus* L.); Rukmani; Morphological parameters; Yield performance; Pyuthan district

1 Introduction

Agriculture is the Nepalese economy's major sector, contributing 23.95% to the national GDP (Mehata et al., 2023; Ibitoye and Kolawole, 2022). Approximately 66% of the population is involved in agriculture for their livelihood (FAO, 2022). The total cultivated agricultural land in the present context is 3,091,000 ha, and the total uncultivated agricultural land is 1,030,000 ha, representing 21% and 7% of the total land area of Nepal, respectively (MoALD, 2021; NARC, 2012). Due to the availability of diverse agroecologies, Nepal has great potential to grow a variety of commodities within different geographical locations. Nepalese agriculture is dominated by cereal crops, mainly rice, with low productivity, i.e., 3.5 t/ha. Even though vegetables are cultivated in 289,834 ha out of the total cultivated land (MoALD, 2021), they have higher productivity than cereal crops, i.e., 14.5 t/ha.

Okra is an important vegetable crop in the tropical and subtropical regions (Parajuli, 2015). The crop is cultivated for its young, tender fruits, which are used in curry and soups after cooking. It is a good source of vitamins A and B, protein, and minerals (Yadav et al., 2024). It is also an excellent source of iodine and is useful for the treatment of goiter. Fruits are also dried or frozen for use during off-season. The top 10 producers of okra in the world

include India, Nigeria, Mali, Sudan, Pakistan, Egypt, etc., where the leading country is India with 13 t/ha productivity. In Nepal, the total cultivated area of okra is 9,584 ha with a production of 110,565 mt and a yield of 11.54 (MoALD, 2022). The spring season crop is cultivated during the end of February or the beginning of March, and the rainy season is sown in June/July (Kumar et al., 2019). In analyzing the trend of vegetables in Nepal, it seems highly fluctuating, where in the case of okra, the area and production have increased by 12.2% each while yield has declined by 0.2% (Ghimire et al., 2018; Gemede et al., 2015). Although the productivity is nearer to the world's leading countries, the major constraint for the decrease in production is the insect pests and diseases mainly caused by the stem borer and yellow vein mosaic virus not only in Nepal but also in Asian countries (Belbase et al., 2020; Lee, 2017).

Pyuthan district is part of the Lumbini province and covers an area of 1,365 m^2. The total population of the Pyuthan district is 232,019 according to the census of 2078. Until 2078/079 in Pyuthan district, the location for cultivation is 1,185 ha with a production of 14,888 Mt and Productivity of 12.6 Mt. Tons/ha and the area covered by the vegetable zone is 395 ha. and productivity of 13.5 mt/ha. The working area of the vegetable zone is in 29 wards of 6 local levels (Poudel and Khadka, 2018; Singh et al., 2014). The project implementation unit, Pyuthan, is gradually expanding the area for vegetables by spreading advanced technology, promoting mechanization, building various infrastructures including increasing production and productivity of vegetables and reducing costs, creating employment opportunities, and establishing vegetable-based industries (PMAMP, 2023). In the Pyuthan district okra is cultivated in 10.48 ha with a production of 306mt and yield of 7.29 (MoALD, 2022).

Different hybrid and local varieties of okra are under practice on growing and farmers select random varieties from agro-vets and don't get the desired yield from the crop in specific locations. So it is very important to research different varieties of okra based on yield so the farmer can get maximum benefit from the varieties they select in the specific location. Even the recommended varieties of okra in Nepal are general, not location-specific according to MoALD, so such research is mandatory.

2 Materials and Methods

The research was carried out on a farmers' farm in Maranthana village Pyuthan district, Nepal. Geographically, the experimental field is situated at Latitude: 28° 6' 39" N, Longitude: 82° 54' 44" E, and elevation of 1,001 masl. The duration of the experiment was from 29th March 2023 to 15th July 2023. The average temperature of maximum and minimum of 30 °C and 12 °C respectively, is located in sub-tropical climates and moderate zone.

2.1 Experimental design

This experiment was carried out in Randomized Complete Block Design (RCBD) with five varieties which include Arka Anamika, Rukmani, Raja F1, Special-45, and Arzine hybrid with four replications. All varieties were randomized separately in each replication block. Altogether there were 20 plots. Individual plots were 3 m in length and 2 m in breadth. Spacing was 30×30 cm^2, in which the plot consisted of five rows with nine plants each. Altogether 45 plants per plot. The net experimental plot area was 6 m^2, having a plot-plot spacing of 50 cm, block-block spacing of 1 m, and a 50 cm border, the total area for experimental research was 208 m^2.

2.2 Research materials

Seeds used in experimental fields include Arka Anamika, Rukmani, Raja F1, Special-45, and Arzine hybrid which were brought from nearby Agro-vet of Pyuthan district. Seeds were treated with thiram fungicide and primed for 24 hours before sowing. The field was prepared by 2-3 plowing followed by planking. Seed sowing was done by line sowing at a depth of 3 cm. Plants from the same treatment as filler plants were used for gap filling, which was conducted 15 days after sowing. Intercultural operation is very crucial for determining final yield and was carried on 15-day intervals from sowing for 4 times.

2.3 Data collection methods

Plant height, branches per plant, pod length, pod diameter, pod weight and no of pods per plant were measured at different time intervals after sowing. Pods were collected every seven-day interval after the first harvest, up to three times up to 90 DAS. Pod length, pod diameter, and whole plot weight were determined at each harvest.

2.4 Data analysis methods

Data were entered in MS Excel 2010, and analysis was conducted using the open-source software package Gen Stat V 15.1.08. Analysis of variance was computed, and the least significant difference (LSD) was set at 0.05 level of significance (LOS). Duncan's multiple range test (DNMRT) was performed to compare the means between treatments that were found to be significantly different.

3 Results and Analysis

Generally, the entire hybrid variety used in the research showed a high degree of variation in terms of yield and yield parameters, including plant height, primary branches, pod length, pod diameter, pods/plant, yield/plant, and weight/plant. The results showed a significant average mean growth in the height of plants of all varieties up to 90 DAS (Table 1). The maximum height (29.44) was attained by the variety Rukmani F1 at all the growth stages, followed by Arzine F1 (27.59), Arka Anamika (26.21), and Special-45 (22.28). Similarly, the minimum height of the plant was attained by the Raja F1 (20.74). According to (Mehata et al., 2023) highest plant height was achieved by Chiranjeevi F1 in 72 DAS (162.55). Likewise, (Mehata et al., 2022) maximum height was achieved by Arka Anamika, i.e., (226.15) (not average mean growth) in 84 DAS, and the Rukamni variety obtained in our study was 29.44. In comparison to those studies, plant height was smaller. This might be because of the genotypic differences between the varieties and other environmental factors are also might be responsible.

Table 1 Effect of treatments on plant height

Treatment	Plant height					
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Arka Anamika	4.60^{a}	5.92^{ab}	8.45^{b}	11.72^{c}	16.80^{b}	26.21^{b}
Rukmani	5.18^{bc}	6.04^{b}	8.59^{bc}	11.83^{c}	18.03^{b}	29.44^{c}
Raja	4.98^{b}	5.57^{a}	7.51^{a}	10.23^{a}	13.71^{a}	20.74^{a}
Special-45	5.48^{c}	6.10^{b}	7.92^{a}	10.91^{b}	14.63^{a}	22.28^{a}
Arzine	6.11^{d}	6.19^{c}	9.10^{c}	12.27^{c}	17.07^{b}	27.59^{c}
LSD(0.05)	0.30	0.43	0.52	0.64	1.91	2.60
F-test	***	***	***	***	**	***
SEm(±)	0.30	0.14	0.16	0.20	0.62	0.84
CV(%)	3.8	4.6	4.1	3.7	7.8	6.7
Grand mean	5.27	6.11	8.32	11.39	16.05	25.25

Note: *Significant at 5% level of significance, **Significant at 1% level of significance, ***Significant at 0.1% level of significance, LSD: least significant difference, SEm: Standard error of the mean, CV: coefficient of difference, DAS: Days After Sowing

Similarly, the study shows the highest number of primary branches was observed in Arzine (3.00) in 90 DAS and the lowest number of primary branches was observed in Arka Anamika (Table 2). The number of primary branches in 2 varieties (Arka Anamika and Special-45) gradually increased to 75 DAS and decreased to 90 DAS. Whereas, Rukmani, Raja F1, and Arzine show the gradual increase in primary branches in different DAS. It was reported that F1 Glory shows the highest branch number, and Arka Anamika recorded the lowest, whereas the highest number was observed in the Chiranjeevi F1 and the lowest number was recorded in Gunjan, respectively (Mehata et al., 2022). The average data observed in the primary branches shows that the highest number of the branches was recorded in Arzine (3.00), followed by Rukmani (2), Special-45 (2), Raja F1 (2), and Arka Anamika (2).

Furthermore, the study shows that Arka Anamika has the highest pod diameter among other varieties (5.83) at 90 DAS (Table 3). The lowest pod diameter was observed in Raja F1 (4.66) whereas the same value of pod diameter was observed in Rukmani and Special 45 (5.16) respectively. The average pod diameter highest Arka Anamika was followed by Arzine hybrid (5.25) at 90 DAS with a significant level at (p<0.001). Accordingly, a result was observed by Mehata et al. (2022) and Maldonado-Peralta et al. (2021).

Table 2 Effect of treatments on primary branches

Treatment	Primary branches of different varieties of okra on different days				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Arka Anamika	1.40^{b}	1.80^{c}	2.30^{c}	2.40^{b}	2.00^{a}
Rukmani	1.30^{b}	1.65^{bc}	2.10^{bc}	2.30^{b}	2.55^{d}
Raja	1.05^{a}	1.30^{a}	1.50^{a}	1.75^{a}	2.15^{b}
Special-45	1.30^{b}	1.50^{ab}	1.95^{b}	2.20^{b}	2.35^{a}
Arzine	1.45^{b}	1.70^{bc}	2.10^{bc}	2.75^{c}	3.00^{e}
LSD(0.05)	0.21	0.22	0.31	0.14	0.11
F-test	*	**	**	***	***
SEm(±)	0.06	0.07	0.10	0.09	0.53
CV(%)	10.6	9.2	10.2	8.5	3.1
Grand Mean	1.30	1.59	2.00	2.21	2.41

Note: *Significant at 5% level of significance, **Significant at 1% level of significance, ***Significant at 0.1% level of significance, LSD: least significant difference, SEm: Standard error of the mean, CV: coefficient of difference, DAS: Days After Sowing

Table 3 Pod diameter of different varieties of okra

Treatment	Pod diameter of different varieties of okra from 60 DAS		
	60 DAS	75 DAS	90 DAS
Arka Anamika	5.33^{b}	5.50^{bc}	5.83^{c}
Rukmani	4.83^{ab}	4.83^{a}	5.16^{b}
Raja	4.66^{a}	4.91^{ab}	4.66^{a}
Special-45	5.08^{ab}	5.08^{abc}	5.16^{b}
Arzine	4.91^{ab}	5.66^{c}	5.25^{b}
LSD(0.05)	0.60	0.61	0.22
F-test	NS	*	***
SEm(±)	0.19	0.19	0.07
CV(%)	7.9	7.7	2.9
Grand Mean	4.96	5.20	5.21

Note: *Significant at 5% level of significance, **Significant at 1% level of significance, ***Significant at 0.1% level of significance, LSD: least significant difference, SEm: Standard error of the mean, CV: coefficient of difference, DAS: Days After Sowing

In the study of the yield parameters, the maximum pod length was observed in Rukmani (14.80) in 90 DAS. Arka Anamika and Arzine hybrid show a similar pod length (13.50), whereas the minimum pod length was recorded in the Raja F1 hybrid (11.75) (Table 4). The highest pod number of all varieties was observed in 60 DAS but found to decrease at 75 DAS gradually, but again it was recorded in the increase of the pod length at 90 DAS. Rukmani varieties were recorded with the highest average pod length (15.25) even at 60 DAS. On comparison with other verities, maximum pod length was recorded with Rukmani, followed by Arzine and Arka Anamika with the same value, and special-45 (13.08), followed by the smallest value, Raja, with the significant level (p<0.01). The result does not coincide with Mehata et al. (2022) and Mehata et al. (2023) because of the varietal difference and experimental factor.

“Upon further analysis of the yield parameters, the average pod number at 90 DAS showed that the highest pod numbers were recorded for Arka Anamika and Rukmani (5.50), followed by Arzine (4.75), with the lowest observed in Raja and Special-45 (4.00), all at a significant level (p<0.01) (Table 5)." According to Mehata et al. (2022) and Mehata et al. (2023), Punjab selection (7.10) and Arka Anamika (3.80) recorded the highest pod number where my research coincided with the Mehata et al. (2023). The weight gained per pod at different growth stages is presented, showing that the Rukmani and Arzine varieties recorded the highest weight per pod (14.50), followed by Arka Anamika (13.75), with the lowest weight per pod observed in Raja and Special-45 (13.0) (Table

6). These differences were not statistically significant, and the grand mean was 13.75, as shown in similar results reported by Singh et al. (2022)."

Table 4 Pod length (cm) of different varieties of okra

Treatment	Pod length (cm) of different varieties of okra from 60 DAS		
	60 DAS	75 DAS	90 DAS
Arka Anamika	13.67^{b}	12.67^{a}	13.50^{bc}
Rukmani	15.25^{c}	12.42^{b}	14.08^{c}
Raja	12.17^{a}	11.34^{b}	11.75^{a}
Special-45	13.42^{b}	12.92^{b}	3.08^{b}
Arzine	14.58^{bc}	13.00^{b}	13.50^{bc}
LSD(0.05)	1.11	0.94	0.87
F-test	***	**	**
SEm(±)	0.36	0.43	0.28
CV(%)	5.2	4.9	4.3
Grand Mean	13.80	12.47	13.18

Note: *Significant at 5% level of significance, **Significant at 1% level of significance, ***Significant at 0.1% level of significance, LSD: least significant difference, SEm: Standard error of the mean, CV: coefficient of difference, DAS: Days After Sowing

Table 5 Average pod number of different varieties of okra

Treatments	Average pod number of different varieties of okra at 90 DAS
Arka Anamika	5.50^{b}
Rukmani	5.50^{b}
Raja	4.00^{a}
Special-45	4.00^{a}
Arzine	4.75^{ab}
LSD	0.86
F-test	**
SEm(±)	0.28
CV(%)	11.8
Grand Mean	4.75

Note: *Significant at 5% level of significance, **Significant at 1% level of significance, ***Significant at 0.1% level of significance, LSD: least significant difference, SEm: Standard error of the mean, CV: coefficient of difference, DAS: Days After Sowing

Table 6 Average pod weight of different varieties of okra

Treatment	Average pod weight of different varieties of okra at 90 DAS
Arka Anamika	13.75
Rukmani	14.50
Raja	13.00
Special-45	13.00
Arzine	14.50
LSD	1.47
F-test	NS
SEm(±)	0.47
CV(%)	7.0
Grand Mean	13.75

Note: LSD: least significant difference, SEm: Standard error of the mean, CV: coefficient of difference, DAS: Days After Sowing

Furthermore, results showed that average yields per plant were maximum recorded with varieties Rukmani (79.50), followed by Arka Anamika (76.25) and Arzine (69.00), and the lowest results obtained by Special-45 and Raja (52.0) with the significant level (p<0.01) and grand mean of 65.78 (Table 7). This finding of conformity is shown by Singh et al. (2022), where Mehata et al. (2022) found Punjab selection with the maximum average yield per plant (s200.42). This could be a result of the field's higher level of soil organic matter content or the variation in okra's genotype. Since all of these varieties are assessed under the same soil, management, and agroclimatic conditions, variations in yield and yield characteristics among them may be understood as varietal differences resulting from genetic variables and their interaction with environmental circumstances.

Table 7 Average yield per plant (g) of different okra varieties

Treatment	Average yield per plant in (g) at 90 DAS
Arka Anamika	76.25[b]
Rukmani	79.50[b]
Raja	52.00[a]
Special-45	52.00[a]
Arzine	69.00[ab]
LSD	17.07
F-test	**
SEm(±)	5.54
CV(%)	16.9
Grand Mean	65.8

Note: *Significant at 5% level of significance, **Significant at 1% level of significance, ***Significant at 0.1% level of significance, LSD: least significant difference, SEm: Standard error of the mean, CV: coefficient of difference, DAS: Days After Sowing

4 Conclusion and Recommendation

The outcome of the experiment demonstrates that several plant characteristics aid in forecasting the total yield and effectiveness of a particular plant. On average, the overall yield is expected to reach 65.75 g for a plant in our field experiment. Production greatly varies with pod length, diameter, pod number, and the number of primary branches in all five varieties, i.e. Arka Anamika, Rukamani, Raja F1, Special-45, and Arzine. Among the five varieties, the Rukmani variety shows a higher yield followed by the Arka Anamika. Therefore, through our experimental findings, I recommended Rukmani And Arka Anamika as a suitable variety to the farmers for effective yield and productivity in the Pyuthan district. Commercial farmers of the Pyuthan district must select location-specific high-performing varieties which include Arka Anamika and Rukmani for high yielding from nearer their agrovet.

The study is limited due to the changing weather and climatic conditions of Pyuthan. The findings may not represent the large area due to the lack of time to conduct research and limited access to leveled land which found difficulty in maintaining homogenous field conditions. A single field trial may not be enough to provide the conclusion. Thus to get valid results several varietal trials in different locations must be conducted with diverse climatic conditions.

Authors' contributions

Unish Nepali carried out the molecular genetic studies, participated in the sequence alignment, and drafted the manuscript. Raju Khatri carried out the immunoassays. Sushmita Adhikari and Susmita Adhikari participated in the sequence alignment. Swekxya Pathak participated in the design of the study and performed the statistical analysis. Pradip Baniya conceived of the study and participated in its design and coordination and helped to draft the manuscript. All authors read and approved of the final manuscript.

Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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