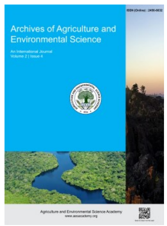
Archives of Agriculture and Environmental Science 9(1): 151-155 (2024)
https://doi.org/10.26832/24566632.2024.0901021

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes



ORIGINAL RESEARCH ARTICLE

Effect of different nitrogen levels on yield and yield attributes of okra (*Abelmoschus esculentus* L.)

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ARTICLE HISTORY

Received: 25 January 2024
Revised received: 07 March 2024
Accepted: 14 March 2024

Keywords

Arka Anamika
Nitrogen
Okra
Pod
Yield

ABSTRACT

Farmers in Lamjung have been unable to maximize okra performance and yield due to being unaware of the ideal fertilizer dosage. A field experiment was carried out at Sundarbazar-7, Lamjung during the period from March to June 2023 to understand the optimal N level to enhance the growth and yield of okra. A Randomized Complete Block Design (RCBD) was used to set up the experiment with the seven treatments *viz.* control, 40, 55, 70, 85, 100, and 115 kg N ha-1 each had three replications. A hybrid variety Arka Anamika mostly used by farmers in Lamjung was used. Recorded data on yield and yield contributing parameters were subjected to statistical analysis and results revealed a significant effect of the treatments on the yield and yield attributes of okra. Plants treated with T6(100 kg N ha-1) had the highest number of fruits per plant (13.10), fruit length (15.84cm), weight of a single pod (15.84 g), and total fruit yield of 14.74 t ha-1. The lowest number of fruits per plant (7.93), fruit length (9.29 cm), single fruit weight (9.29 g), and yield (8.12 t ha-1) were recorded from the control treatment T1 (0 kg N ha-1). Meanwhile, the impact of treatment T6(100 kg N ha-1) was found to be effective compared to other treatments under study. Based on these findings, the experiment suggests okra farmers to use 100 kg N ha-1 to maximize okra performance and yield considering the soil health.

Citation of this article: Pokhrel, S., Neupane, B., & Chapagain, S. (2024). Effect of different nitrogen levels on yield and yield attributes of okra (*Abelmoschus esculentus* L.). *Archives of Agriculture and Environmental Science*, *9*(1), 151-155, https://dx.doi.org/10.26832/24566632.2024.0901021

INTRODUCTION

Okra (*Abelmoschus esculentus* L.), also referred to as a lady's finger, is an annual herbaceous plant that is semi-cross-pollinated in nature's annual vegetable crop (Belbase *et al.*, 2019). It is cultivated in tropical and sub-tropical parts of the world and is one of the important nutritious vegetable crops grown around the year in Nepal. With a productivity of 11.3 tons per hectare, Nepal's total okra production was 122,101.6 metric tons under 10,781.4 hectares (MoAD, 2016). In Lamjung, okra is grown across a 30-hectare area, yielding a total production of 300 metric tons, with an average productivity of 9.95 metric tons per hectare. (Ministry of Agriculture and Livestock Development, 2021). The following make up each 100 g edible portion of okra pods: Ca 84 mg, P 90 mg, Fe 1.2 mg, water 88.6 g, energy 144 kJ (36 kcal), protein 2.1 g, carbohydrate 8.2 g, fat 0.2 g, fibre 1.7 g, ascorbic acid 47 mg, thiamin 0.04 mg, riboflavin 0.08 mg, niacin 0.6 mg, and β-carotene 185 µg (Sorapong, 2012). The young immature okra pod is consumed as a nutritious dish in a variety of ways (fresh, boiling, dried, or fried), and the seed is used to make oil (Hai & Thao, 2022). The fruits are picked and eaten like vegetables when they are immature (Singh *et al.*, 2014). Okra is a short-duration vegetable crop and nutrient management practices greatly influence the growth, yield, and quality of okra. All plant species require nitrogen, phosphorus, and potassium as the fundamental major nutrient for growth and development. Okra shows a strong and favorable response to chemical fertilizers (Kumar *et al.*, 2016). Nitrogen plays a crucial role in facilitating vegetative growth, enhancing dry matter accumulation, and promoting the development of reproductive parts in plants. Nitrogen is necessary for the formation of chlorophyll, protein synthesis, and nucleic acids production, all of which promote robust growth, expansion of leaves, development of roots, and increased photosynthetic activity, consequently improving both crop yield and quality (Singh *et al*., 2020). In okra, adding nitrogen increases the pod's weight, diameter, fruit count per plant, and seed count per pod (Singh & Daljeet, 2016). An adequate quantity of nitrogen promotes the metabolism of carbohydrates into proteins. Normal metabolic activity can only continue in the presence of nitrogen. The following variables of okra: plant height, number of leaves and branches/plant, number of fruits/ plant, fresh fruit weight, and total fresh fruit output were all significantly impacted by nitrogen (Uwah *et al*., 2010). However, over-application of nitrogen can extend the growth period and postpone crop maturity, potentially leading to physiological disorders in crop plants (Obreza & Vavrina, 1993). Depending on the soil fertility, various rates of applied nitrogen are suggested for okra, varying from 80 to 150 kg/ha (Moench *et al*., 2020). Nepal Agricultural Research Council (NARC) has recommended applying a nitrogen dose of 200kg N per hectare for okra production (Bhandari *et al*., 2019). Recommended nitrogen (N) rates for okra differ greatly according to soil type, climate, and cultivars. A major constraint to okra productivity in Nepal is the lack of proper fertilizer knowledge among Nepalese farmers. Farmers possess limited understanding regarding the impact of various nitrogen doses on vegetative growth, yield, and yield-attributing characteristics. In Nepal, very little site-based research has been carried out to determine the appropriate nitrogen (N) fertilizer dose for okra. Thus, a real field trial was necessary to determine the amount of nitrogen required, which changes according to environmental factors, for any given climate in the study area. Therefore, this experimental trial aimed to evaluate the influence of different nitrogen levels on the yield and yield attributes of okra, aiming to determine the optimal nitrogen (N) recommendation to achieve the maximum production desired by farmers.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in the experiment field under the Department of Horticulture, Institute of Agriculture and Animal Science, Lamjung Campus. It lies at an elevation of 610m with latitude of 28.13°N and longitude of 84.42°E.

Research design and treatment details

The experiment was carried out in single factor Randomized Block Design (RCBD) with seven treatments and three replications. The net experimental plot area was 3.375m^2, having plot-plot spacing of 50 cm, and block-block spacing of 75cm thus total area for research was 112.5m^2. Altogether there were 21 plots. The individual plot was 2.25m in length and 1.50m in breadth. Spacing was 45cm×30cm, in which the plot consisted of 5 rows with 5 plants each. Seven treatments were used in the experiment. Out of seven treatments, T1 (control) was control without fertilizer and other treatments involved variations in nitrogen levels at 40, 55, 70, 100, and 115 kg. Constant levels of phosphorus (50 kg) and potassium (30 kg) were applied the same across all treatments. The treatments for each block were assigned randomly.

Horticultural practices

An inter-specific hybrid between *Abelmoschus esculentus* (IIHR20-31) × *A. Manihot* resistant to yellow vine mosaic virus "*Arka anamika*" was used for the research. Primary tillage was performed by the tractor 15 days before sowing followed by 2 light ploughing in the experimental area. 20Mt. ha^{-1} of well-rotted FYM was applied during the field preparation stage. Seeds were soaked for more than 24 hours to break dormancy and line sowing was done keeping line to line distance of 45 cm, seed to seed distance of 30 cm at a depth of 1.5 cm (Kumar *et al*., 2019). The fertilizers used for the source of nitrogen, phosphorus, and potassium were urea, diammonium phosphate (DAP), and muriate of potash (MOP) respectively. Nitrogen was applied in three split doses. Half the dose of nitrogen as urea and the full dose of phosphorus and potassium were applied during the time of field preparation. The remaining 50% of urea was top dressed at 30 and 45 DAS. After 7 days of germination, only one healthy seedling per spot was retained; dead or weak ones were replaced by stock plants from plot borders. Okra was irrigated daily until establishment, then irrigated based on crop needs. Weeding was done in 10-day intervals. All other horticultural practices were uniformly applied across all treatments.

Data collection

Five plants were randomly chosen from each plot for the collection of necessary data. Data was taken after 50% flowering of the plant at 3-day intervals. The yield parameters collected during the research period were the number of pods per plant, pod length, single pod weight, and pod yield per hectare. The number of pods was counted manually, pod length was measured manually using a measuring scale, the weight of the pods was measured by using a digital weighing machine and their average means were recorded.

Statistical analysis

Data was collected and recorded in Microsoft Excel. Data was subjected to one-way analysis of variance (ANOVA) using R-studio version 4.3.1. Means separation was carried out by using Duncan's Multiple Range Test (DMRT) at a 5% level of significance (Gomez & Gomez, 1984). Agricolae package in R-studio was used for visual interpretation of the results.

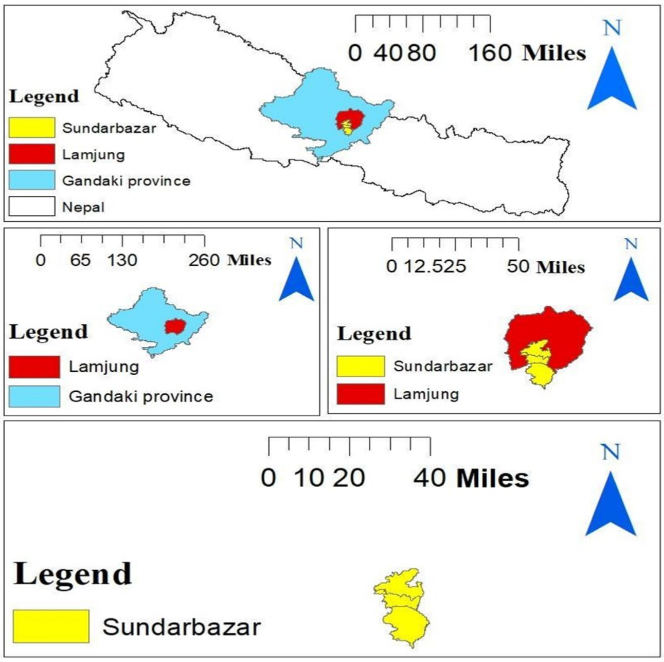

Figure 1. *Map of study area (Source: National Geographical, Nepal).*

RESULTS AND DISCUSSION

Effect of different levels of nitrogen on the number of pods per plant

Table 2 represents the effect of different levels of nitrogen on number of pods per plant. The results indicate that treatments were significantly affected by the application of different levels of nitrogen. The highest number of pods/plants (13.10) was recorded in T6(100kg N/ha) which was statistically similar to T7 (115kg N/ha) with a mean value of 11.34. And the lowest number of pods/plants (7.93) were there in T1 (control) which was statistically similar to T2(9.00) and T3(7.93). The control treatment may have resulted in fewer pods per plant due to its lower nutritional condition. Nitrogen promotes flower opening, fruit setting, and fruit development (Yang *et al*., 2023). Normal metabolic activity can only continue in the presence of nitrogen. The application of N may have increased plant vigor and use of proteinaceous metabolites in the formation of new tissues which increases in number of pods per plant. This is fully supported by the findings of Bagadi & Chakravorty (2023).

Effect of different levels of nitrogen on pod length of okra

The length of the pod represented in Table 3, was significantly affected by the application of different levels of nitrogen. The longest pods (15.84cm) were recorded in T6(100kg N/ha) which was statistically similar to T7 (115kg N/ha) with a mean value of 14.39 cm. And the shortest pods (9.29 cm) were there in T1 (control) which is statistically similar to T2 (11.08 cm) and T4 (11.28 cm). An increase in pod length might result from the favorable effect of nitrogen on the production of chlorophyll, amino acids, and enzymes which impacted cell elongation and expansion. A sufficient amount of nitrogen in the soil promotes improved nutrient uptake and transport in the plant (Muratore *et al*., 2021) which increases the amount of nutrients going toward the development and elongation of pods. Longer pods result from increased nitrogen availability, which promotes cell proliferation and division in the pod tissue. This result coincides with the result of (Singh & Daljeet, 2016) who reported that the longest pods(9.4cm) were recorded at the rate of (100 kg N/ha) and the shortest under control treatment.

Table 1. Different treatments used in the experiment.

Treatments	Doses (Kg N/ha)
T1	Control
T2	40
T3	55
T4	70
T5	85
T6	100
T7	115

Table 2. Effect of different levels of nitrogen on number of pods per plant of okra.

Treatments (Kg N/ha)	At harvest
T1 (Control)	7.93[d]
T2 (40)	9.00[cd]
T3 (55)	7.93[d]
T4 (70)	10.07[bc]
T5 (85)	9.57[cd]
T6 (100)	13.10[a]
T7 (115)	11.34[ab]
LSD	1.68
Mean	9.86
F test	***
CV%	9.56

Note: LSD=Least Significant Difference, CV=Coefficient of variation, "***" denotes significant at 0.001 probability level, Means with the same letters are not significantly different based on DMRT at a 5% level of significance.

Table 3. Effect of different levels of nitrogen in pod length (cm) of Okra.

Treatments (Kg N/ha)	Average pod length at harvest (cm)
T1 (Control)	9.29[d]
T2 (40)	11.08[cd]
T3 (55)	11.59[c]
T4 (70)	11.28[cd]
T5 (85)	13.00[bc]
T6 (100)	15.84[a]
T7 (115)	14.39[ab]
LSD	2.003165
Mean	12.35
F test	***
CV%	9.12

Note: LSD=Least Significant Difference, CV=Coefficient of variation, "***" denotes significant at 0.001 probability level, Means with the same letters are not significantly different based on DMRT at a 5% level of significance.

Table 4. Effect of different levels of nitrogen in single pod weight (g) of Okra.

Treatments (kg N/ha)	Average pod weight at harvest (g)
T1 (Control)	11.93[c]
T2 (40)	12.40[c]
T3 (55)	13.26[bc]
T4 (70)	14.20[abc]
T5 (85)	13.67[abc]
T6 (100)	16.70[a]
T7 (115)	15.90[ab]
LSD	12.91
Mean	13.95
F test	**
CV %	12.91

Effect of different levels of nitrogen on average pod weight of okra

Individual fruit weight is a critical factor in determining overall yield along with the number of fruits per plant and the weight of each fruit significantly contributes to the total harvest. The single pod weight of okra was significantly varied under the various doses of nitrogen as shown in Table 4. The maximum weight of a single pod (15.84 g) was recorded in T6(100kg N/ha) which was statistically similar to T7(14.39 g) and the lowest single pod weight (9.29 g) was observed in T1(Control) which was statistically similar with T2(11.08 g), and T4 (11.28 g). Variations in the pod length and the diameter of pods account for the changes in pod weight among the different nitrogen levels. Nitrogen's impact on stomatal conductance enhances the allocation of photosynthetic materials. This facilitates the synthesis of sugars and starches and its mobility from the source to sink within plants (Kanneh *et al*., 2016) results increase in the average pod weight of okra. (Bake & Omar, 2023) also found a similar result where the maximum average pod weight was observed with the application of 100kg N/ha.

Effect of different levels of nitrogen on total yield (t/ha) of okra

The data regarding the effect of nitrogen on the total yield of okra shown in Table 5 revealed that the total yield was significantly affected by different levels of nitrogen. The significantly greater yield (14.74 t/ha) as noted under T6(100kg N/ha) was statistically similar to T7(14.33 t/ha) against the minimum (8.12 t/ha) recorded under T1 (Control) which was statistically similar with T2(9.70 t/ha) and T3(9.50 t/ha). A sufficient supply of nitrogen significantly boosts fruit yield by stimulating rapid vegetative development, raising rates of photosynthesis, and enhancing general plant health (Noor, 2023). The variations in the number of pods per plant and the weight of pods per plant account for the changes in yield among the different nitrogen levels. As the number and weight of fruits were higher in the plant from 100 kg N/ha, the ultimate fruit yield was higher in those plants. A similar type of result was obtained by (Ibrahim *et al*., 2023) who noted the highest yield of okra under the nitrogen level of 100 kg/ha.

Conclusion

From this experiment, it is concluded that different level of nitrogen has a significant effect on the yield and yield attributes of okra. Okra plants treated with T6(100kg N/ha) show a significant improvement in the yield and yield attributing characters with respect to fruits per plant, fruit length, single fruit weight, and total yield as compared to other treatments under the study. In conclusion, we recommend using 100kg N/ha for okra cultivation in Lamjung and similar agro domains. However, Further research and field trials are needed to validate these findings across different seasons and locations.

ACKNOWLEDGEMENT

We would like to acknowledge the Department of Horticulture, Institute of Agriculture and Animal Science, Lamjung Campus, Nepal for providing space to conduct this research.

Authors contribution

Conceptualization: SP, BN, and SC; Methodology: SP and SC; Software and validation: BN, SC, and SP; Formal analysis and investigation: SC; Resources: BN; Data curation: SC; Writing—original draft preparation: SC; Writing—review and editing: SP and SC.; Visualization: SC and SP; Supervision: SP. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: No conflicts of interest exist, according to the authors, with the publishing of this paper.

Ethical approval: Not applicable.

Data availability: The data that support the findings of this study are available on request from the corresponding author.

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