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Influence of Plant Density and Nitrogen Application on Yield and Economic Viability of Okra (Cv. Arka Anamika) in Manipur

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Abstract

The present study investigated the effect of plant densities and nitrogen levels on yield and economics of Okra (Abelmoschus esculentus L. Moench) cv. Arka Anamika under Manipur conditions from April 2021 to August 2021. The experimental field was laid out in the horticulture department of the College of Agriculture at Central Agricultural University, Imphal, India. The experiment was framed in Factorial Randomized Block Design constituting three levels of spacing (S_1-60 cm× 60 cm, S_2-60 cm× 45 cm and S_3-60 cm×30 cm) and four levels of Nitrogen (N_0-0 kg/ha, N_1-125 kg/ha, N_2-150 kg/ha, and N_3-175 kg/ha). The current study revealed that wider spacing (S1-60 cm×60 cm) resulted in the highest yield parameters, including fruit length (13.01 cm), fruit girth (1.47 cm), fruit weight (14.89 g), number of fruits per plant (28.14), fruit yield per plant (421.80 g), and harvest index (26.35%). However, fruit yield per plot (12.52 kg) and fruit yield per hectare (19.32 t/ha) were maximum at closer spacing. A nitrogen level of N3-175 kg/ha resulted in the greatest fruit length (13.17 cm), fruit girth (1.50 cm), and fruit weight (15.17 g). Conversely, the N2-150 kg/ha level produced the highest number of fruits per plant (29.17), fruit yield per plant (439.54 g), fruit yield per plot (11.11 kg), fruit yield per hectare (17.14 t), and harvest index (27.47%). Interaction of spacing and nitrogen also had significant effect in yield and economics. Treatment combination T_9 is considered the best in the current study due to highest gross return (Rs 643096), net return (Rs 486828) and BC ratio (3.014:1).

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INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench), also known as Ladies finger, is a herbaceous, semifibrous, annual and dicotyledonous plant. It belongs to the family Malvaceae. Immature pods of Okra are very popular with diners due to their rich nutrition and unique taste. Fresh pods can be consumed as vegetables in various ways, such as in salads, soups, stews, or simply boiled. It contains 36.66–50.97 g of utilizable carbohydrate, 10.25–26.16 g of crude proteins, 0.56–2.49 g of crude fat, 11.97–29.93 g of crude fiber,111.11–311.95 mg of calcium, 25.62–59.72 mg of phosphorus, 18.3–36.68 mg of iron, and 16–29 mg of vitamin C per 100 g of pod on dry weight basis [1].

India is the largest producer of Okra with 6.18 million tonnes of production followed by Nigeria with 1.82 million tonnes [2]. However, productivity and export potential of Okra in India is still not up to the mark. Thus, standardized package of practices is required to be followed.

Proper plant spacing ensures optimal yield, while both insufficient and excessive spacing can lead to poorer quality and reduced yield, respectively [3]. With an increasing population, the Okra yield per unit area increases till a certain limit, beyond which resources for the plant become limited and the yield decreases [4]. Sufficient amount of nitrogen is crucial for healthy vegetative growth and achieving desirable yields [5]. Verma et al. [6] observed that the application of nitrogen gave higher yield of Okra pods.

MATERIALS AND METHODS

The present investigation was carried out during summer 2021 at the experimental field of the Department of Horticulture, College of Agriculture, Central Agricultural University, Imphal, India located at 24° 81′ N and longitude 93° 89′ E and at an altitude of 784 m above mean sea level. The layout of the experimental field was carried out in Factorial Randomized Block Design (FRBD) constituting three levels of spacing (S_1-60 cm× 60 cm, S_2-60 cm× 45 cm and S_3- 60 cm×30 cm) and four levels of Nitrogen (N_0- 0 kg/ha, N_1-125 kg/ha, N_2-150 kg/ha and N_3-175 kg/ha). The field layout and random assignment of treatments to plots were conducted according to the statistical methods outlined by Panse & Sukhatme [7]. Data on the fruit length (cm), fruit girth (cm), fruit weight (g), number of fruits per plant, fruit yield per plant (g), fruit yield per plot (kg) and fruit yield per hectare (t), Harvest Index, B:C ratio was recorded and subjected to statistical analysis, the test of significance (F-test) and critical difference (C. D.) at 0.05 probability [8].

RESULTS AND DISCUSSION

Fruit Length and Girth

During the course of observation, maximum length (13.01 cm) and girth (1.47 cm) of fruit was recorded in the widest spacing S_1-60 cm×60 cm (Table 1). The length and girth of fruit was increased with increase in spacing. These findings are consistent with some earlier studies [3, 9, 10]. Fruit length and girth was influenced positively by Nitrogen. The highest fruit length (13.17 cm) and fruit girth (1.50 cm) was obtained by the Nitrogen level N_3-175 kg/ha. Treatment combination T_{11}-60 cm×45 cm and 175 kg/ha (13.20 cm) recorded highest fruit length and lowest length of fruit was recorded by T_3-60 cm× 30 cm and 0 kg/ha (12.38 cm). Interaction of spacing and Nitrogen was not significant in terms of fruit girth. Pod diameter is a key factor in assessing Okra yield and preferred pod size, with larger and longer green pods being more desirable and marketable [11].

Fruit Weight

The fresh weight of Okra pod is directly linked to the yield and demonstrated a notable reaction to various treatments involving spacing, nitrogen, and their combination. As plant population increased, the fresh weight of the Okra pod decreased. The greatest fruit weight was observed in the widest spacing, S1 (14.89 g), and at nitrogen level N3 (15.17 g) (Table 1). Treatment combination T_7-60 cm×60 cm spacing and 150 kg/ha nitrogen recorded the maximum fruit weight (15.61 g).

The observations were in agreement with some earlier studies [12, 13]. Plants with the widest spacing produced fruits with superior quality characteristics, likely because each plant received ample nutrients, moisture, and sunlight due to low plant density. These widely spaced plants probably allocated more of their photo assimilates to their fruits, resulting in larger and heavier fruits as compared to those from plants with closer or intermediate spacing [9].

Number of Fruits and Fruit Yield Per Plant

Spacing significantly influenced both the number of fruits and the fruit yield per plant (Table 1). The highest number of fruits per plant (28.14) and the highest yield per plant (421.80 g) were recorded at a

spacing of 160 cm×60 cm. Similar findings of higher number of green fruits at wider spacing were recorded by few researchers [14–16]. Paththinge recorded maximum fruit yield per plant up to spacing of 60 cm×90 cm.

Table 1. Effect of spacing and Nitrogen on yield parameters of Okra cv. Arka Anamika.

Treatments		Fruit length (cm)	Fruit girth (cm)	Fruit weigh t (g)	Number of fruits per plant	Fruit yield per plant (g)	Fruit yield per plot (kg)	Fruit yield per hectare (t)	Harvest Index (%)
60 cm×60 cm	S1	13.01	1.47	14.89	28.14	421.80	7.59	11.72	26.35
60 cm×45 cm	S2	12.77	1.44	14.61	26.67	391.27	9.39	14.49	24.77
60 cm×30 cm	S3	12.62	1.40	14.21	24.39	347.79	12.52	19.32	22.37
	S.E (d) (±)	0.07	0.01	0.12	0.52	7.92	0.22	0.34	0.51
	C.D	0.15	0.02	0.24	1.09	16.44	0.46	0.70	1.06
0 kg/ha	N0	12.55	1.37	13.33	21.54	287.08	7.40	11.42	19.27
125 kg/ha	N1	12.73	1.42	14.72	27.07	399.31	10.11	15.60	25.57
150 kg/ha	N2	12.76	1.44	15.04	29.17	439.54	11.11	17.14	27.47
175 kg/ha	N3	13.17	1.50	15.17	27.81	421.88	10.71	16.53	25.68
	S.E (d) (±)	0.08	0.01	0.14	0.61	9.15	0.25	0.39	0.59
	C.D	0.17	0.02	0.28	1.26	18.98	0.53	0.81	1.22
T1=60 cm×60 cm and 0 kg/ha	S1N0	12.65	1.41	13.65	21.47	293.24	5.28	8.15	19.40
T2=60 cm×45 cm and 0 kg/ha	S2N0	12.62	1.39	13.62	21.53	293.11	7.03	10.86	19.72
T3=60 cm×30 cm and 0 kg/ha	S3N0	12.38	1.32	12.71	21.63	274.90	9.90	15.27	18.69
T4=60 cm×60 cm and 125 kg/ha	S1N1	13.13	1.44	15.12	29.39	444.32	8.00	12.34	28.09
T5=60 cm×45 cm and 125 kg/ha	S2N1	12.60	1.43	14.60	27.33	399.27	9.58	14.79	25.51
T6=60 cm×30 cm and 125 kg/ha	S3N1	12.45	1.41	14.45	24.50	354.33	12.76	19.69	23.10
T7=60 cm×60 cm and 150 kg/ha	S1N2	13.08	1.47	15.61	31.47	491.21	8.84	13.64	30.26
T8=60 cm×45 cm and 150 kg/ha	S2N2	12.68	1.43	15.01	29.45	441.55	10.60	16.35	27.66
T9=60 cm×30 cm and 150 kg/ha	S3N2	12.51	1.41	14.51	26.60	385.86	13.89	21.44	24.47
T10=60 cm×60 cm and 175 kg/ha	S1N3	13.17	1.56	15.17	30.23	458.41	8.25	12.73	27.64
T11=60 cm×45 cm and 175 kg/ha	S2N3	13.20	1.50	15.20	28.37	431.15	10.35	15.97	26.19
T12=60 cm×30 cm and 175 kg/ha	S3N3	13.14	1.44	15.14	24.83	376.07	13.54	20.89	23.21
	S.E (d) (±)	0.15	0.02	0.23	1.05	15.85	0.44	0.68	1.02
	C.D	0.30	NS	0.49	2.17	32.87	NS	NS	NS

Nitrogen also exhibited a significant impact on both the number of fruits per plant and the fruit yield per plant. Among nitrogen treatments, N2-150 kg/ha resulted in the highest number of fruits (29.17) and fruit yield (439.54 g) per plant. Treatment combination T_7-60 cm×60 cm and 150 kg/ha recorded maximum number of fruits per plant (31.47) and highest yield (491.21 g) per plant. However, the lowest number of fruits were recorded in T_1-60 cm×60 cm and 0 kg/ha (21.47) and the lowest fruit yield per

plant was exhibited by T_3 (274.90 g). Gemechu [12] found that the number of tender fruits and fruit weight per plant of Okra increased with the increased interaction of main factor (inter-row spacing and nitrogen fertilizer rate) from 30 cm to 60 cm and 0 kg/ha to 92 kg/ha nitrogen.

Fruit Yield Per Plot

The fruit yield per plot is the most important factor which determines the total yield (Table 1). As the plant population varies along with the spacing treatments the yield also varies. The higher is the plant population higher will be the yield up to a certain limit. The maximum yield per plot was exhibited by S_3 (12.52 kg) and nitrogen treatment N_2 recorded highest yield (11.11 kg). Interaction of spacing and nitrogen was not significant for fruit yield per plot.

Fruit Yield Per Hectare

The maximum yield per hectare was recorded by S_3 (19.32 t) and nitrogen treatment N_2 exhibited maximum yield (17.14 t). N_2 (17.14 t) was at par with N_3 (16.53 t) in terms of yield per hectare (Table 1). It implies that though the yield significantly increased up to N_2 (150 kg/ha), while higher nitrogen N_3 (175 kg/ha) had no significant effect on the yield. Saimbhi & Padda [17] recorded increase in yield with increase in nitrogen up to 134 kg/ha. However, some studies [5, 18–20] recorded highest yield with the application of 150 kg/ha nitrogen. Interaction of spacing and nitrogen was not significant for yield per hectare, probably due to very little difference between the treatment combinations. Though, the highest fruit yield per plot (13.89 kg) and per hectare (21.44 t) was recorded by T_9. The best treatment can be concluded only with the help of economics of the production.

Harvest Index

The highest harvest index was recorded in S_1 (26.35%), succeeded by S_2 (24.77%), and S_3 (22.37%). S_1 was significantly different from all the other treatments (Table 1). The maximum harvest index in wider spacing is probably due to higher weight of fruits in wider spacing. Nitrogen treatment N_2 recorded the maximum harvest index (27.47%) followed by N_3 (25.68%), N_1 (25.57%), and N_0 (19.27%). This indicated that, up to 150 kg/ha, there is positive influence of nitrogen on the yield parameters of Okra. Interaction of spacing and nitrogen was not significant for harvest index in the present study.

Effect of Spacing and Nitrogen on Economics and B:C Ratio of Okra Cultivation

The economics of Okra cultivation, influenced by varying spacing, nitrogen levels, and their interaction, is assessed in terms of cultivation cost (Rs./ha), gross returns (Rs./ha), and net returns (Rs./ha) (Table 2). The cultivation cost of Okra was determined by considering both fixed costs and input costs involved in the cultivation process.

Table 2. Economics of Okra Cv. Arka Anamika under different treatments.

Treatment combinations	Cost of cultivation (Rs./ha)	Yield (t/ha)	Gross return (Rs./ha)	Net returns (Rs./ha)	Benefit cost Ratio (B: C)
T_1 (S_1N_0)	156328	8.15	244370	88042	0.563
T2 (S2N0)	156928	10.86	325676	168748	1.075
T3 (S3N0)	157828	15.27	458163	300335	1.903
T_4 (S_1N_1)	158328	12.34	370266	211938	1.339
T5 (S2N1)	158928	14.79	443630	284702	1.791
T6 (S3N1)	159828	19.69	590552	430724	2.695
T_7 (S_1N_2)	158728	13.64	409344	250616	1.579
T_8 (S_2N_2)	159328	16.35	490608	331280	2.079
T9 (S3N2)	160228	21.44	643096	482868	3.014
T10 (S1N3)	159128	12.73	382011	222883	1.401
T11 (S2N3)	159728	15.97	479056	319328	1.999
T12 (S3N3)	160628	20.89	626783	466155	2.902

Note: Market value of Okra was Rs. 30/kg.

The higher cultivation cost was associated with the closer spacing S3 as compared to S2 and S1, likely due to the increased plant population requiring a higher seed rate, thereby raising the overall expenditure. Gross return (Rs. 643096) and net return (Rs. 482868) was maximum at treatment combination T9 (60 cm×30 cm spacing and 150 kg/ha nitrogen) which is due to higher yield per hectare (13.89 t), while lower yield per hectare (5.28 t) resulted in minimum gross return (Rs. 244370) and net return (Rs. 88042) was found in T1 (60 cm×60 cm spacing and 0 kg/ha nitrogen).

The benefit–cost ratio (BCR) is a metric used to evaluate the relationship between the costs and benefits of a project or investment by dividing the present value of expected benefits by the present value of costs. A BCR greater than 1.0 indicates a favourable investment with a positive net present value. In the present study, the highest BCR of 3.014 was observed in the treatment combination T9 (60 cm×30 cm spacing and 150 kg/ha nitrogen), while the lowest BCR of 0.563 was found in the treatment combination T1 (60 cm×60 cm spacing and 0 kg/ha nitrogen). The maximum BCR in T9 is probably due to higher yield and subsequently, higher returns in comparison to the incurred cost. Conversely, a lower yield per hectare could result in comparatively lower returns, thus reducing the BCR.

SUMMARY AND CONCLUSION

The present investigation revealed that wider spacing (S1-60 cm×60 cm) resulted in maximum yield parameters, including fruit length (13.01 cm), fruit girth (1.47 cm), fruit weight (14.89 g), number of fruits per plant (28.14), fruit yield per plant (421.80 g), and harvest index (26.35%). However, fruit yield per plot (12.52 kg) and fruit yield per hectare (19.32 t/ha) were maximum at closer spacing (S3-60 cm×30 cm). Nitrogen level of N_3-175 kg/ha recorded maximum fruit length (13.17 cm), fruit girth (1.50 cm) and fruit weight (15.17 g). However, N_2-150 kg/ha recorded maximum fruits per plant (29.17), fruit yield per plant (439.54 g), fruit yield per plot (11.11 kg), fruit yield per hectare (17.14 t), and harvest index (27.47%).

Interaction of nitrogen and spacing positively influenced the yield parameters of Okra. Treatment T_{11} recorded fruits with highest length (13.20 cm), girth (1.50 cm), and weight (15.20 g). Treatment T_{10} recorded highest number of fruits per plant (30.23) and fruit weight per plant (458.41 g). However, treatment T_9 recorded highest fruit yield per plot (13.89 kg) and fruit yield per hectare (21.44 t). The gross returns (Rs. 643096), net returns (Rs. 482868), and BCR (3.014:1) was highest for T_9. Thus, treatment T_9 is considered the best treatment in the present study.

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