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Effect of Integrated Nitrogen Management on Growth and Yield of Okra at Sundarbazar, Lamjung, Nepal

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Authors' contributions

This work was carried out in collaboration among all authors. Author NKC designed, performed the experiment, recorded data, analyzed data, and drafted the manuscript. Author PR and DB provided guidance and helped in data analysis and recording data. Author KBK supervised the experiment and critically revised the initial draft. All authors read and approved the final manuscript.

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ABSTRACT

Integrated Nutrient Management (INM) is a crucial approach to improving the sustainable yield of crops in an environmentally friendly manner. In this study, a field experiment was conducted at Lamjung Campus, Sundarbazar, Lamjung, from March 2022 to June 2022 to evaluate the effect of integrated nitrogen management on the growth and yield parameters of okra and to find out the suitable nitrogen management system in okra. A randomized full-block design was utilized in the investigation, with seven treatments and three replications. The treatments consisted of a control (T_1) and six other combinations of nitrogen sources, with each treatment receiving 50% of its nitro-

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gen from chemical fertilizers and 50% from organic sources. The amount of organic manure was calculated based on the nitrogen content of the manures. Farmyard manure (FYM), poultry manure, vermicompost, mustard cake, and goat manure were tested as organic sources. The effect of treatment combinations was evaluated in terms of plant height, stem diameter, leaf numbers, days to first flower opening, days to first fruit maturity, number of pods per plant, length, and diameter of pods, and yield ha^{-1}. The findings revealed that integrated nitrogen management strategies had a substantial impact on okra growth and output. Among all the treatments, 50% recommended N through chemical fertilizer + 50% N through poultry manure (T_4), which gave the highest number of pods per plant (19.87), yield per ha (13.59 t/ha), and shortest days taken to first flowering (46.54 days) and plant height (54.80 cm), followed by T_2, while the control treatment (T_1) yielded the lowest. These findings suggest that the application of 50% recommended N through chemical fertilizer + 50% N through poultry manure is an effective strategy for obtaining a high yield of okra in the study area.

Keywords: Growth; Nitrogen; Okra; Poultry Manure; Yield.

1. INTRODUCTION

Okra is one of the well-known vegetable crops that belong to the genus Abelmoschus, family Malvaceae [1] having somatic chromosome number of Okra 2n=130 [2]. It was initially planted in Egypt in the 12th century after being discovered in tropical America [3]. It is called Lady's Finger in England, Gumbo in the United States of America, and Bhindi in Nepal. It is a short-duration hardy vegetable crop; the immature green fruits are used as a vegetable and are generally marketed in fresh but sometimes in canned or dehydrated form. It contains plenty of vitamins, calcium, potassium, and other minerals. The present consumption of vegetables is 195g/day/capita which is very low compared to the recommended dose by dietitians 375g/day/capita (FAO/WHO,2003). Therefore, there is a big gap between the requirement and the supply of vegetables in Nepal. Successful okra production may contribute partially to solving vegetable scarcity in summer. Over a total area of 9,584 hectares, the nation produced 110,565 metric tons of okra, with a productivity of 11.54 tons per hectare [4].

Despite its yield potential, it has not yet achieved optimum yields due to a continuing deterioration in soil fertility [5] which could be attributed to the imbalanced use of fertilizers in the mid-hill of Nepal. Crop nutrient requirements are determined by soil texture, preceding vegetation cover type, cropping intensity, and soil moisture [6]. Nitrogen (N) is the most crucial, among various nutrients required for adequate nutrition and a high yield of okra [5]. Inappropriate nitrogen sources, uneven fertilizer application, and a high rate of nitrogen leaching are all factors in low crop yields [7]. Nitrogen's primary role is to contribute to plant growth characteristics, thereby influencing yield and quality parameters, which are generally directly correlated [8] and it is major essential for the synthesis of chlorophyll, protein, nucleic acid, hormones, and vitamins, as well as cell division and elongation [9]. Between 1997 and 2003, the use of nitrogen fertilizers for vegetable production increased by 21% [10].

Unfortunately, N deficiency is widespread in Nepal on account of low available soil N and organic matter content as a result of nitrification and leaching losses. Imbalanced application of chemical fertilizers for obtaining higher yields is linked to soil acidity, poor physical structure, and nutrient retention characteristics, which negatively affect crop growth and yield. Moreover, it increases the cost of production and causes economic loss [11]. The use of organic manure should be promoted to sustain soil fertility over time. This is because the nutrients in organic manures are released more slowly and are kept in the soil for a longer period, ensuring a lasting residual effect [12]. According to Shedeed and Hassan [13] it has also been reported that organic manure has a direct impact on plant growth by providing all necessary macro and micronutrients in accessible forms during mineralization, hence increasing the physical and physiological qualities of soils. There are different types of nitrogen sources including farmyard manure, poultry manure, goat manure, vermicompost, mustard cake, etc. Combining the use of organic and chemical fertilizers increases yields, improves soil health, and reduces pollution problem issues brought on by improper use of chemical fertilizers alone [14].

Keeping all the above facts in view this experiment was conducted under mid-hill conditions of Nepal to evaluate the effect of integrated nitrogen management on the growth and yield parameters of okra and to find out the suitable nitrogen management system in okra.

2. MATERIALS AND METHODS

2.1 Experimental Site and Soil Analysis

The experiment was laid out in the field of horticulture research farm of Lamjung Campus, Sundarbazar, Lamjung, Nepal. Geographically, the experimental field is situated at 28° 07' 01.49" N latitude, 82° 17' 48.40" E longitude, and an elevation of 857 masl. The duration of the experiment was from March 2022 to June 2022. The location falls in the mid-hill area with a humid subtropical climate.

The soil of the studied area was tested before commencing the experiment, and soil falls on the texture loam having a pH value of about 5.06, organic matter 1.826, total nitrogen (0.09%), available phosphorus (6.36 kg/ha), and available potassium (125.6 kg/ha). Moisture percentage was recorded at 25.85%.

2.2 Experimental Material, Design, and Treatment

This experiment used the Arka Anamika variety of okra, which was registered in Nepal in 2010 [15]. The seed of Arka Anamika was taken from Krishi Sahayog Kendra Tatha Biyu Bhijan Agro-Vet Sundarbazar, Lamjung. The yield potential of the variety is 20 t/ha. The experiment was laid out in (Randomized Complete Block Design RCBD) with seven treatments and three replications. The net area of the experimental field was 84.6 m^2 (14.1 m × 6 m) in which the individual plot measured 2.7 m^2 (1.8m × 1.5 m). There were 21 plots in total, with a spacing of 0.25m between each plot and a spacing of 0.75m between each replication. Nitrogen (N), phosphorus (P), and potassium (K) were applied in all treatments except in the control treatment. The recommended dose of fertilizer for okra is 160 N: 120 P_2O_5: 60 K_2O as per [16] which was used in the study. In our experiment nitrogen (N) was applied through chemical fertilizer (urea) and organic manures (FYM, Poultry Manure, Goat Manure, Vermicompost, and Mustard Cake) whereas Phosphorus and Potassium were applied through single super phosphate and muriate of potash respectively. One-month-old, decomposed poultry manure, FYM, goat manure, vermicompost, and freshly prepared mustard cake were collected and sun-dried to reduce moisture. Nutrient contents in soil and manure were tested in the Soil and Fertilizer Testing Laboratory, Pokhara, Kaski before the commencement of the experiment.

2.3 Cultural Activities

Cultural practices, such as seed and sowing, irrigation, gap filling, weeding, plant protection measures, and picking of fruits, were followed in the experiment. Water-primed seeds were sown on March 4th with two seeds placed in each spot to reduce missing plants, and the soil was compacted over the seeds to facilitate germination. Light irrigation was applied immediately after sowing, and medium irrigation was done every second day until the first month, after which heavy irrigation was done every week. Gap filling was done 16 days after sowing using plants from the same treatment as filler plants. Weeding was done three times, at 30 DAS, 40 DAS, and 50 DAS, while plant protection measures, such as spraying of Imidacloprid 17.5 SL (0.25%) to protect against insect pests like jassids and whitefly and spraying of Dimethoate 30 EC (0.03%) to control fruit borers in okra crops, were applied as needed. The fruits were hand selected when they were green tender and of marketable size, and they were then immediately weighed and subjected to various observations.

Table 1. Nutrient content of organic manures

Amending substances	Nutrients containing %		
	N	P	K
FYM	0.5%	0.5%	0.5%
Poultry manure(layers)	2.85%	4.1%	2%
Goat manure	2.21	0.77	3.89
Vermicompost	2.52	1.69	2.08
Mustard Cake	4.61	1.5	1.3

Table 2. Treatment details of the experimental field

SN	Treatment	Details
1	T_1	Control
2	T_2	100% recommended N through chemical fertilizer
3	T_3	50% recommended N through chemical fertilizer + 50% N through farm yard manure (FYM)
4	T_4	50% recommended N through chemical fertilizer + 50% N through poultry manure
5	T_5	50% recommended N through chemical fertilizer + 50% N through vermicompost
6	T_6	50% recommended N through chemical fertilizer + 50% N through mustard cake
7	T_7	50% recommended N through chemical fertilizer + 50% N through goat manure

2.4 Harvesting and Data Collection

Five randomly selected plants from each plot were used to collect various types of growth and yield contributing data for okra and their average value was considered as one plot for each parameter. Plant height, stem girth, number of leaves per plant, Days to first flowering, and days to first fruit maturity were measured at different intervals after sowing. Fruits were collected every third day after the first harvest up to 20 times. The number of fruits per plant, fruit length, fruit girth, and individual fruit weight were determined at each harvest. Yield per plot was converted to ton per hectare.

2.5 Statistical Analysis

Data regarding growth and yield traits were analyzed statistically by one-way analysis of variance (ANOVA) by using R- Studio 4.2.2. Treatment means were separated by least significant differences (LSD) at 5%, 1%, and 0.1% probability outlined by Gomez and Gomez [17].

3. RESULTS

3.1 Germination %

There was a non-significant difference in germination percentage among a different combination of inorganic and organic manures but T_4 (50% recommended N through chemical fertilizer + 50% N through poultry manure) recorded the maximum germination percentage which was 68.60 % followed by 65.53% at T_2 (50% recommended N through chemical fertilizer + 50% N through FYM). The minimum plant germination percentage (62.43 %) was recorded at T_1 (control).

Table 3. Effect of integrated nitrogen management on germination Percentage of okra

Treatments	Germination %
T_1	62.43^{b}
T_2	65.53^{ab}
T_3	65.20^{ab}
T_4	68.60^{a}
T_5	65.06^{ab}
T_6	65.46^{ab}
T_7	65.41^{b}
SEM (±)	1.20
LSD (α=0.05)	3.72
CV	3.20%
Grand mean	65.24
p-value	NS

*Means in column followed by similar letter/s are not significantly different, CV=coefficient of variation, NS= non-significant; *= p<0.05; **p<0.01; ***= p<0.001 in LSD*

3.2 Plant Height

The vegetative growth parameters of plant height were influenced significantly at 30, 45, and 60 DAS due to different treatments of integrated nitrogen management as shown in Table 4. The highest plant height was recorded in T_4 at 60 DAS (54.80cm) while the lowest plant height was recorded in Control treatment T_1 (40.13 cm).

3.3 Number of Leaves per Plant

The number of leaves per plant also showed significant differences when the okra plant was treated with various treatments of integrated nitrogen management. The maximum number of leaves per plant was observed in T_4 at 60 DAS **(**14.70) while the minimum number of leaves per plant was seen in the control treatment i.e., T_1 (10.85).

3.4 Stem Diameter (mm)

Integrated nitrogen management exerted a significant difference in the stem diameter. The maximum stem diameter was found in the treatment T_4 at 60 DAS (15.50 mm) which was seen to be statistically par with T_3 (14.26 mm) and T_6 (14.25 mm). The maximum stem diameter was then followed by T_2, T_7, and T_1 respectively. The minimum stem diameter was found in the control treatment (11.11 mm).

3.5 Days to First Flower Opening

The results revealed that the different combinations among treatments show significant differences in the days of the first flower opening. The least days to took to first flowering was observed when plants were treated with (T_4) 50% recommended N through chemical fertilizer + 50% N through poultry manure (46.54 days) which was statistically par with treatment (T_5) 50% recommended N through chemical fertilizer + 50% N through vermicompost (48.26 days). The maximum days it took to first flowering was observed in the control treatment T_1 (53.37 days).

3.6 Days to First Fruit Maturity

There was a significant difference in days to first fruit maturity among various treatments of combined use of inorganic and organic manures. (T_4) 50% recommended N through chemical fertilizer + 50% N through poultry manure shows the least days to take to first fruit maturity (52.54 days) which was statistically similar to the treatment T_5 (54.07 days). While control Treatment T_1 (59.37 days) took the maximum of days to first fruit maturity.

3.7 Number of Pods per Plant

Integrated application of organic and inorganic fertilizers showed significant differences in the result on the number of pods per plant. The number of pods *per* plant was highest (19.87) in the treatment T_4 (50% recommended N through chemical fertilizer + 50% N through poultry manure) which was at par with the plots that received 100% recommended N through chemical fertilizer (T_2) and 50% recommended N through chemical fertilizer + 50% N through vermicompost (T_5). The lowest number of pods per plant was found in control (T_1).

Table 4. Effect of integrated nitrogen management on the growth attributes of okra

Treatments	Plant height(cm)			Number of leaves per plant			Stem diameter(mm)		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_1	10.15^{c}	23.02^{c}	40.13^{c}	3.36^{e}	6.345^{c}	10.85^{c}	3.21^{c}	6.91^{c}	11.11^{c}
T_2	11.97^{bc}	27.04^{abc}	45.30^{b}	3.95^{b}	6.980^{bc}	12.54^{bc}	3.74^{bc}	8.56^{ab}	12.83^{b}
T_3	13.53^{ab}	28.48^{ab}	45.46^{b}	3.85^{bc}	7.79^{b}	13.06^{b}	4.30^{ab}	8.27^{ab}	14.26^{ab}
T_4	15.39^{a}	31.32^{a}	54.80^{a}	4.32^{a}	9.39^{a}	14.70^{a}	5.10^{a}	9.29^{a}	15.50^{a}
T_5	12.71^{bc}	28.36^{ab}	44.80^{bc}	4.04^{b}	7.40^{b}	11.40^{bc}	4.52^{ab}	8.80^{ab}	13.38^{b}
T_6	11.67^{bc}	25.25^{bc}	44.26^{bc}	3.52^{de}	7.03^{bc}	11.66^{bc}	3.61^{bc}	7.73^{bc}	14.25^{ab}
T_7	11.96^{bc}	25.14^{bc}	42.47^{bc}	3.66^{cd}	7.26^{bc}	11.70^{bc}	4.07^{bc}	8.19^{ab}	12.83^{b}
SEM (±)	0.8043	1.528	1.453	0.0838	0.314	0.518	0.277	0.341	0.528
LSD (α=0.05)	2.478	4.70	4.479	0.258	0.968	1.597	0.855	1.05	1.63
CV	11.15%	9.82%	5.55%	3.80%	7.29%	7.32%	11.76%	7.16%	6.79%
Grand mean	12.48	26.94	45.31	3.81	7.45	12.27	4.08	8.25	13.46
p-value	*	*	***	***	***	**	**	**	**

*Means in column followed by similar letter/s are not significantly different, CV=coefficient of variation, NS= non-significant; *= p<0.05; **p<0.01; ***= p<0.001 in LSD*

Table 5. Effect of integrated nitrogen management on the reproductive attributes of okra

Treatments	Days to first flower opening	Days to first fruit maturity
T_1	53.37^{a}	59.37^{a}
T_2	48.53^{d}	54.70^{cd}
T_3	48.88^{cd}	54.83^{cd}
T_4	46.54^{e}	52.54^{e}
T_5	48.26^{de}	54.07^{de}
T_6	52.67^{b}	57.04^{b}
T_7	50.46^{bc}	56.11^{bc}
SEM (±)	0.5637	0.5522
LSD (α=0.05)	1.7372	1.7016
CV	1.9694%	1.7226%
Grand mean	49.583	55.526
p-value	***	***

*Means in column followed by similar letter/s are not significantly different, CV=coefficient of variation, NS= non-significant; *= p<0.05; **p<0.01; ***= p<0.001 in LSD*

Table 6. Effect of integrated nitrogen management on the yield attributes of okra

Treatments	Number of pods per plant	Length of pods(cm)	Diameter of pods(mm)	Yield ton per hectare
T_1	12.16^{d}	9.523^{c}	10.70^{c}	8.20^{c}
T_2	17.746^{ab}	12.436^{ab}	12.31^{ab}	11.18^{b}
T_3	15.67^{bc}	11.63^{b}	11.917^{ab}	10.24^{bc}
T_4	19.87^{a}	13.74^{a}	12.77^{a}	13.59^{a}
T_5	17.44^{ab}	12.01^{ab}	12.14^{ab}	10.82^{b}
T_6	13.62^{cd}	11.13^{b}	11.38^{bc}	9.72^{bc}
T_7	15.19^{bc}	11.37^{b}	11.87^{ab}	9.99^{bc}
SEM (±)	0.8355	0.55250	0.34280	0.6855
LSD (α=0.05)	2.574	1.7024	1.056279	2.112
CV	9.06%	8.184%	5.001%	11.26%
Grand mean	15.96	11.692	11.872	10.53
p-value	***	**	*	**

*Means in column followed by similar letter/s are not significantly different, CV=coefficient of variation, NS= non-significant; *= p<0.05; **p<0.01; ***= p<0.001 in LSD*

3.8 Length of Pods (cm)

Integrated nitrogen management on different treatments shows significant differences in the pod length of the okra pod. Maximum pod length was recorded in treatment T_4 (13.74 cm) which was followed by T_2, T_5, T_3, T_7, and T_6 respectively. Treatment T_4 was found statistically par with treatment T_2 (12.43 cm) and treatment T_5 (12.01 cm). The minimum pod length was recorded in the control treatment (T_1) of pod length (9.52 cm).

3.9 Diameter of Pods (mm)

There was a significant difference in the diameter of pods among different treatments of integrated nitrogen management. The maximum diameter of the pod was observed in treatment T_4 **(**12.77 mm) which was also statistically similar to treatments T_2 (12.31mm), T_5 (12.14 mm), T_3 (11.91 mm), and T_7 (11.87 mm). The minimum diameter of pods was observed in the control T_1 (10.70 mm).

3.10 Yield ton Per Hectare

The study revealed that nitrogen-based integrated nitrogen management on different treatments exerted a significant difference in the yield of okra. Treatment (T_1) control gave the lowest 8.20-ton yield per hectare while the maximum yield per hectare was observed in treatment T_4 (13.59 tons/ha).

4. DISCUSSION

In comparison to the control plot, the number of pods, fruit weight per plant, pod length, pod diameter, and yield per hectare increased significantly, and high values were observed in the poultry manure treated plot, indicating that poultry manure was available in the best form for easy absorption by the plant roots, increasing the plant's morphological growth. The results of morphological parameters such as plant height, number of leaves, and stem diameter improved significantly. When compared to other sources of organic manure, okra grows better on poultry manure in terms of plant height. This demonstrates that poultry manure was easily accessible and in the best form for root absorption, leading to an increase in the morphological growth of plants which is corroborated by the findings of [18]. The increased number of leaves per plant with poultry manure application in treatments was related to the importance of improved crop plant vegetative growth [19]. The applications of poultry manure may have increased the amount of nitrogen available to plants through mineralization, and nitrogen is known to stimulate plant growth [20]. The effects of integrated nitrogen management on the number of leaves were found to be greatest in poultry manure, correlating with previous research by Fagwalawa and Yahaya [21]. An increase in stem diameter might be due to an increase in the vegetative growth of the plant. It has been discovered that nutrient concentration influences how many days it takes for flowers to open [22] hence the earlier reproduction of okra under poultry manure could be attributed to the rapid release of nitrogen into the soil [23].

The study of Adekiya and Agbede [24] shows the nutrient release may have coincided with the specific phenological demands of okra. The increased number and weight of okra pods as a result of poultry manure application could be linked to the easier solubilization of liberated plant nutrients, resulting in improved nutrient status and soil water-holding capacity. The findings were consistent with those of [25] in turmeric (*Curcuma longa*). Conforming to Premsekhar and Rajashree [26] in okra (*A. esculentus*) in which they found that superior physical and biological features of the soil, resulting in greater nutrient availability to the plants, might be related to increased crop production response to the application of organic manure.

In comparison to other organic manures, poultry manure considerably increased plant growth, yield, mineral content, and proximate composition of okra due to its high soil chemical characteristics, which may be connected to its lowest C: N ratio, lignin, and lignin: N ratio [27]. Similarly, both liquid and solid excreta are excreted without loss of urine due to which poultry manure is richer in organic matter and essential plant nutrients than the manure of other animals [28].

Although no significant effect was recorded on the germination percentage of plants, T4 (50% recommended N through chemical fertilizer + 50% N through poultry manure) recorded the maximum germination percentage. A study by Boateng, et al. [29] showed that poultry manure decomposes rapidly and releases all essential nutrients for the crops, which facilitates quick and efficient nutrition uptake by the plants, potentially leading to maximum germination percentage in the treated crops.

5. CONCLUSION

The combination of 50% recommended N through chemical fertilizer and 50% N through poultry manure management practice resulted in significant improvement in most growth attributes of okra, including yield and yield attributes. Based on the findings, it is suggested to use the combination of 50% recommended N through chemical fertilizer + 50% N through poultry manure to obtain a higher growth and yield of okra in a mid-hill place like Sundarbazar, Lamjung.

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COMPETING INTERESTS

The authors have declared that no competing interests exist.

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