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RESEARCH ARTICLE

RESPONSE OF OKRA [*ABELMOSCHUS ESCULENTUS (L.) MOENCH*] TO NITROGEN DOSE AND SPACING ON GROWTH AND YIELD UNDER MULCH CONDITION, IN CHITWAN, NEPAL

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ABSTRACT

Commercial farmers in Chitwan are unaware of optimum spacing and fertilizer dose which limits the performance and yield of okra [*Abelmoschus esculentus (L.) Moench*]. An experiment was conducted to assess the response of okra to different levels of nitrogen 60, 90 and 120kg.ha-^{1} and 30×30, 45×30 and 60×30cm^{2} spacing under plastic mulched condition in Bharatpur-16, Chitwan from March to May 2018, using Ramdomized Complete Block Design (RCBD) with 3 replications. A hybrid variety of okra (Venus plus) mostly employed by farmers in Chitwan was used. Data were collected from ten randomly selected plants from the central rows in each plot and growth parameters were analyzed of various yield related parameters taken. The tallest plants were for 120kg.ha-^{1}N and for the 30×30cm^{2} spacing. Pods from the interaction of 90kg.ha-^{1}N for spaced at 45×30cm^{2} had the widest, the heaviest and the longest. Pods per plant were greatest for plants receiving 120kg.ha-^{1}N spaced at 60×30cm^{2}. Yield was best and cost:benefit (BC) ratio was most favorable for 90kg.Nha-^{1} treatment and for plants spaced at 45×30cm^{2}. Overall data indicates that the nitrogen dose of 90kg.ha-^{1}N with a spacing of 45× 30cm^{2} showed the most effective result statistically and economically.

KEYWORDS

Nitrogen, Spacing, Yield attribute, okra.

1. INTRODUCTION

Okra (*Abelmoschus esculentus* (L). Moench) belonging to the family malvaceae is one of the most popular summer vegetable crops of Nepal and grown widely in Jhapa, Morang, Saptari, Dhanusha, Mohattari, Rautahat, Bara, Chitwan and Kailali. It's every 100 grams (g) green pod contains 1.9 g protein, 6.4 g carbohydrate, 1.2 g fiber, 13 mg vitamins C and 66 mg calcuim (Bose & Som, 1986). The total production of okra across the country was 122,101.6 metric tons under the area of 10,781.4ha with the productivity of 11.3ton ha^{-1} (MoAD, 2015-2016). Vegetable production and productivity are seriously affected due to the use of low yielder varieties, imperfect plant density, inappropriate planting date, soil fertility, fertilizer used, heavy attack of various insect pests, weeds etc. The yield of the okra and income is generally determined by these factors, including plant nutrients and proper spacing.

The optimum spacing avoids the strong competition between plants for growth factors such as space, solar radiation, moisture and nutrients. With increasing plant population, yield per unit area increases till the certain limit, beyond which resources for plant become limited and yield decreases. In 2008, Paththinige et al., reported that, appropriate plant densities could lead to optimized plant growth and fruit yields whereas too high or low plant densities result in comparatively lower yields and poor fruit quality of okra. Optimum plant population is important for yield of okra, as plant growth and yield are affected by intra and inter-row spacing (Amjad et al., 2002). Optimum plant spacing is responsible for higher yield due to efficient utilization of soil resources and solar radiation (Thavaprakash et al., 2005).

In same manner, sufficient nitrogen supply improves cell division, foliage production, and photosynthetic activity of the plant, thus producing higher numbers of flowers and fruits as nitrogen fertilizer promote vegetative growth by imparting the elements essential for photosynthesis (Futuless & Bagale, 2007). It encourages the plant foliage and boosts plant growth at every stage because it is an integral part of the chlorophyll, all proteins, enzymes and structural materials (Balasubramania & Palaniappan, 2004). Protein produced due to nitrogen allows the plant leaves to have more surface available for photosynthesis and more carbohydrates synthesized and translocated towards reproductive organs consequently increasing yield. When there is too much growth is redirected to foliage at the expense of reproductive organs and nitrate accumulates in fruits and can be toxic to human health (Sajjan et al., 2002). Nitrogen availability to plants depends on source, soil type and environmental conditions (Salazar et al., 2011).

Farmers in Chitwan are unaware of optimum spacing and fertilizer dose which limited the performance and the yield of the crop. Very few site-based researches have been conducted regarding the appropriate dose of fertilizer and spacing on okra in Nepal. Thus, it is necessary to conduct site-specific research and recommendations regarding use of fertilizer and spacing. Therefore, this research was carried out to determine the best plant density based on spacing and amount of nitrogen on yield and net income of okra var. Venus plus under the existing agro-climatic and plastic mulching conditions of Chitwan.

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2. MATERIALS AND METHODS

The research was conducted in Bharatpur Metropolitan ward no. 16, Dhaddaghari, Chitwan from March to May 2018 in the field of Mr. Hari Bahadur Thapa, a farmer registered in Prime Minister Agriculture Modernization Project (PMAMP), vegetable zone Parbatipur, Chitwan. The geographic location of the site is 27°38'N latitude and 84°20'E longitude at an elevation of 228 m above mean sea level.

2.1 Climatic condition during experimental observation

During cropping period weather data were recorded from meteorological station of National Maize Research Program (NMRP), Rampur, Chitwan, Nepal about 300 meters from research site (Figure 1). The highest average rainfall was recorded during May (137.70mm). The maximum average temperature and minimum average temperature during the experimental period were the highest during April (34.4°C) and May (24.9°C). Similarly, the relative humidity was the highest during May (75.63).

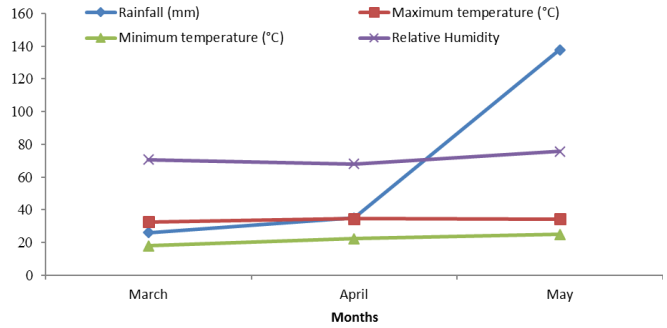

Figure 1: Meteorological data of experimental site during okra growing period at Bharatpur- 16, Chitwan

In the experimental field having sandy loam soil texture with pH of 6.4, one deep plowing and three light plowings were done thoroughly followed by planking was done for field preparation. Well rotted farmyard manure at the rate of 20 Mt.ha^{-1} was applied at the time of field preparation.The recommended dose of fertilizer for okra is 90kg/ha: 60kg/ha: 60kg/ha NPK (AITC, 2017). The P from diammonium phosphate (DAP) and K from muriate of potash (MOP) was applied at soil preparation. Half of the nitrogen as urea was broadcasted at field preparation and the remaining half top dressed at 30 and 45 days after sowing. To control weeds silver plastic mulch of 15microns thick was placed on soil in all plots. Commercial variety mostly used by farmers of Chitwan, Venus plus, which is tolerant to yellow mosaic virus was used. Seeds were soaked in water for 24 hours and 3 seeds directly sown in each hole on 3rd March 2018 in plots of 3×3 m^2. After 7 days, emerged seedlings were thinned out to one plant per hole. The final harvest was on 20th May 2018 when plants were terminated. Sprinkler irrigations were performed at 6-7days interval.

Spacing was one of the factors to be tested in the trial and 3 different spacing were trialed which are listed below:

Table 1: Treatment Combination of Research

Factor A(Spacing) cm^2	Factor B (Nitrogen dose)	Treatment Combinations
30×30 (S1)	60 kg ha^{-1} (N1)	S1N1: 30×30 spacing at 60 kg ha^{-1}
	90 kg ha^{-1} (N2)	S1N2: 30×30 spacing at 90 kg ha^{-1}
	120 kg ha^{-1} (N3)	S1N3: 30×30 spacing at 120 kg ha^{-1}
45×30 (S2)	60 kg ha^{-1} (N1)	S2N1: 45×30 spacing at 60 kg ha^{-1}
	90 kg ha^{-1} (N2)	S2N2: 45×30 spacing at 90 kg ha^{-1}
	120 kg ha^{-1} (N3)	S3N3: 45×30 spacing at 120 kg ha^{-1}
60×30 (S3)	60 kg ha^{-1} (N1)	S3N1: 60×30 spacing at 60 kg ha^{-1}
	90 kg ha^{-1} (N2)	S3N2: 60×30 spacing at 90 kg ha^{-1}
	120 kg ha^{-1} (N3)	S3N3: 60×30 spacing at 120 kg ha^{-1}

The spacings were assigned to plots randomly forming different treatment combinations with the nitrogen doses. Pods were harvested at green maturity, about 9-10 days after anthesis for most pods, before they became fibrous) at intervals of 3 days until as many as 10 harvests had occurred. Ten okra plants were sampled in the inner rows of each treatment and used to record plant height, number of leaves per plant, pod length and fresh pod weight. Data were subjected to analysis of variance (ANOVA) using Microsoft Excel and R software package (2018). The treatment means were separated for significant differences using Duncan Multiple Range Test (DMRT) at 5% level of significance.

3. RESULTS AND DISCUSSIONS

3.1 Number of leaves

The application of different doses of nitrogen had a significant effect on the number of leaves. The number of leaves was found maximum in the treatment of nitrogen with 120 kg ha^{-1} in all stages and was 37 at final harvesting (Table 2). Increase in the application of nitrogen rate was associated with an increase in vegetative growth components of plants and resulted in new leaf formation as suggested by the findings of M. S. (2009). Similar results were reported by (Ghoneim, 2000), who reported that the application of 60 kg N ha^{-1} to okra plants increased leaves per plant. Maximum numbers of leaves were observed in the spacing of 60cm × 30cm (Table 2). This result is supported by M. S. (2009), who reported that the number of leaves per plant was significantly increased as the plant density decreased, and number of leaves decreased as plant density increased. This is because wider spacing provides favorable growth conditions that enhance vegetative growths such as the number of branches which results in higher number of leaves per plant. However, the main effects of plant population and the interaction effect of plant population and nitrogen rate did not show a significant effect on this parameter.

Table 2: Number of leaves under different doses of nitrogen under different spacing.

Source	30 DAS	40 DAS	50DAS	76 DAS (Final harvest)
Nitrogen (kg ha^{-1})				
N1 (60)	6.78^{b}	16.11^{b}	22.56^{b}	34.33^{b}
N2 (90)	7.11^{b}	17.44^{a}	23.89^{a}	35.67^{b}
N3 (120)	7.78^{a}	17.78^{a}	23.89^{a}	36.89^{a}
$LSD_{0.05}$	0.41	0.63	1.1	0.83
p-value	<0.0001***	<0.0001***	0.02975*	<0.0001***
Spacing (cm^2)				
S1 (30× 30)	7.00^{b}	16.89	23.11	35.00^{b}
S2 (45× 30)	7.22^{ab}	17.44	23.67	35.33^{b}
S3 (60× 30)	7.44^{a}	17.00	23.56	36.56^{a}
$LSD_{0.05}$	0.41	0.63	1.1	0.83
p-value	0.01775*	0.1773^{ns}	0.5384^{ns}	0.000431***
Grand mean	7.22	17.11	23.44	35.63
CV%	5.65	3.71	4.69	2.33

Means followed by or sharing the same letters within a column are not significantly different at 5% level of significance; CV=coefficient of variation, LSD=least significant difference at 5%

3.2 Plant height

The height of plant was significantly higher in treatments of nitrogen dose of 120 kg ha^{-1} with 116.44cm at final harvesting stage which was statistically similar with 90 kg ha^{-1} with 115.70cm (Table 3). This result is supported by the finding of Attarde et. al., (2012) who stated that maximum plant height in okra was found to be increased with increase in nitrogen fertilizer rate up to 92 kg ha^{-1} whereas, the lowest height was recorded for untreated plots. The spacing of 30cm × 30cm was with

significant value with maximum height except at 30 DAS which is according to the findings of Arora, et al., (1987) that crowded plants begin to grow upward to receive light, rather than developing laterally. The interaction effect of plant population and nitrogen rate did not show a significant effect on this parameter.

Table 3: Plant height (cm) under different doses of nitrogen under different spacing

Treatments	30 DAS	40 DAS	50DAS	76DAS(Final harvest)
Nitrogen (kg ha^{-1})				
N1 (60)	14.56^{b}	30.60^{b}	43.26^{b}	114.32^{b}
N2 (90)	15.20^{a}	31.91^{a}	44.73^{a}	115.70^{a}
N3 (120)	15.41^{a}	31.92^{a}	44.94^{a}	116.44^{a}
$LSD_{0.05}$	0.48	0.45	0.6	0.83
p-value	0.0041**	<0.0001***	<0.0001***	<0.0001***
Spacing (cm^{2})				
S1 (30× 30)	15.77	31.92^{b}	45.1^{a}	118.04^{a}
S2 (45× 30)	15.06	31.63^{a}	44.20^{ab}	115.37^{b}
S3 (60× 30)	15.34	30.88^{b}	44.04^{b}	116.06^{b}
$LSD_{0.05}$	0.48	0.45	0.6	0.83
p-value	0.06^{ns}	0.00095***	0.00149**	0.0032**
Grand mean	15.06	31.48	44.31	115.49
CV%	3.16	1.42	1.36	0.72

Means followed by or sharing the same letters within a column are not significantly different at 5% level of significance; CV=coefficient of variation, LSD=least significant difference at 5%

3.3 Number of branches

The more the number of branches produced the more likely the yield to be increased. Results from this study showed that the main effect of plant population and nitrogen fertilizer rate had a significant difference in number of branches produced but not from their interaction. The number of branches was found significantly maximum in 120kg ha^{-1} (3) and was statistically similar to 90kg/ha (Table 4). The result of the study is in line with the finding of M. S. (2009) who reported that increasing N application rate up to 150 kg N ha^{-1} was associated with significant progressive increases in number of branches per plant. In 2000, Ghoneim had reported that the application of 120 kg Nha^{-1} to okra plants increased plant height and number of branches. Plant population significantly increased number of branches produced per plant. The maximum number of branches was produced per plant was obtained from the lower plant population (60 cm × 30 cm plant spacing) (Table 4). It can be assumed that plants grown in wider spacing had less competition for moisture and light as compared to plants grown in closer spacing. Thus, the lateral growth of the plant has been favored and tends to produces plants with more lateral branches at wider spacing. In 2003, Wu *et al.* reported that the decrease in branch number as plant population density increased. The increment in number of branches produced per plant in response to the lower plant population is reported by Ekwu and Nwokwu (2012).

Table 4: Number of branches under different doses of nitrogen under different spacing

Treatment	
Nitrogen (kg ha^{-1})	Number of branches
N1 (60)	2^{b}
N2 (90)	3^{a}
N3 (120)	3^{a}
$LSD_{0.05}$	0.39
p-value	0.0195*
Spacing (cm^{2})	
S1 (30× 30)	2^{b}
S2 (45× 30)	2^{b}
S3 (60× 30)	3^{a}
$LSD_{0.05}$	0.39
p-value	0.0195*
Grand mean	3.00
CV%	13.03

Means followed by or sharing the same letters within a column are not significantly different at 5% level of significance; CV=coefficient of variation, LSD=least significant difference at 5%

3.4 Yield and Yield components of okra

3.4.1 Pod length

As shown in Table 5, the length of the pod was significantly affected by the nitrogen dose and spacing. The longest pods were produced by treatment of nitrogen with 90 kg ha^{-1} (20.08cm) and spacing of 60cm × 30cm (19.23cm). The maximum length of pod under treatment 60cm × 30cm may be due to less competition for nutrients and space among the plants owing to the minimum plant population.

The combined treatment of 90kg/ha and 45cm × 30cm had significantly maximum pod length (19.90cm). Similar results were obtained by Khan and Jaiswal (1988) and Pandy and Manocha (1990), who reported that the longest pod was obtained from plants spaced at 45cm × 30cm, receiving N at the rate of 90kg/ha.

3.4.2 Pod diameter

The main effect of plant population and nitrogen fertilizer rate showed significant difference on pod diameter. Similarly, the interaction effect of plant population and nitrogen fertilizer rate showed significant difference on the pod diameter. Pod diameter was significantly maximum in treatment of nitrogen with 90 kg ha^{-1} (3.40cm) and spacing of 60cm × 30cm (3.24cm) (Table 5). The minimum pod diameter was recorded from the plots higher plant population.

Minimum pod diameter at these spacing levels could have resulted from high competition between plants which makes plants produce pods with the smaller sizes as compared to the wider-spaced plants. The interaction of 90 kg ha^{-1} and 45cm × 30cm had significantly maximum pod diameter (3.55cm). This might be due to better nourishment of plants under a higher levels of nitrogen with lower population produced bolder seeds ultimately improved the girth of the pod. These results are in agreement with those reported by Fagaria et al., (1993).

3.4.3 Pod weight

It is not only the number of fruits per plant but individual fruit weight also plays a key role in determining yield. As shown in Table 5, the heaviest pods were produced by the plants at the wider spacing (60cm × 30 cm), while minimum green fruit weight was recorded at the closest spacing. The maximum weight under widest spacing may be due to the increase in the photosynthates production and greater partitioning of metabolites and nutrients towards the reproductive organs. This has eventually happened as a result of reduced competition between widely spaced plants for space, light, nutrients and moisture. These results are in close agreement with those Bajpai et al., (2004) and Harischand et al., (2013).

Fresh pod weight of okra increased with increased rate of N fertilizer up to 120 kg Nha^{-1} which recorded the highest mean values, followed by 90 kg Nha^{-1}. The interaction of 90kg/ha and 45cm × 30cm had significantly maximum pod weight (20.96gm). The result was conformed to the findings of M.S. (2009)

3.4.4 Number of pod per plant

Significantly maximum number of pods per plant was found in treatment of nitrogen with 120 kg ha^{-1} (33) (Table 5). The higher number of pods per plant under increased level of nitrogen may be higher vigor of the plant and utilization of proteinous metabolites for build-up of new tissues. These results are in agreement with those reported by Ambare et al. (2005) and Firoz (2009). The spacing of 60cm × 30cm gave the maximum number of pods per plant (31).

This result can be supported by Ekwu and Nwokwu (2012) who reported that the number of fruit of okra significantly increased with decrease in population density. The maximization of green pods in response to lowering plant population could be since plants grown under low population density have good growth performance since competition for available resources are limited as compared to plants grown under high plant population density. The results indicated that the interaction effect of plant population and nitrogen fertilizer rate did not show a significant difference in the number of green pod yield production per plot.

Table 5: Yield attributing factors influenced by different doses of nitrogen under different spacing

Treatments	Pod length (cm)	Pod diameter (cm)	Pod weight(gm)	Number of pod per plant
Nitrogen (kg ha^{-1})				
N1 (60)	14.08^{c}	2.89^{c}	17.36^{b}	26^{c}
N2 (90)	20.08^{a}	3.40^{a}	18.49^{ab}	30^{b}
N3 (120)	16.97^{b}	3.16^{b}	18.71^{a}	32^{a}
$LSD_{0.05}$	2.82	0.12	1.68	1.38
p-value	<0.0001***	<0.0001***	<0.0001***	<0.0001***
Spacing (cm^{2})				
S1 (30× 30)	16.46^{ab}	3.07^{b}	17.20^{b}	29^{b}
S2 (45× 30)	15.42^{b}	3.14^{ab}	18.03^{ab}	29^{ab}
S3 (60× 30)	19.23^{a}	3.24^{a}	18.33^{a}	31^{a}
$LSD_{0.05}$	2.82	0.12	1.68	1.38
p-value	0.00326**	0.036554*	0.00287**	0.02*
Interaction				
N1 × S1	16.67^{ab}	2.67^{e}	17.38^{bc}	26
N1 × S2	14.02^{bc}	2.93^{cd}	17.44^{bc}	24
N1 × S3	13.80^{c}	3.08^{bcd}	17.06^{c}	27
N2 × S1	16.27^{ab}	3.36^{ab}	18.12^{b}	28
N2 × S2	19.90^{a}	3.55^{a}	20.96^{a}	33
N2 × S3	16.90^{ab}	3.29^{abc}	19.39^{ab}	32
N3 × S1	16.47^{ab}	3.21^{abcd}	19.25^{ab}	32
N3 × S2	15.07^{b}	2.94^{cde}	18.55^{ab}	33
N3 × S3	16.69^{ab}	3.35^{ab}	18.33^{ab}	33
p-value	0.00264**	0.001029**	0.03958*	0.12^{ns}
Grand mean	16.32	3.15	18.19	29.89
CV%	17.29	3.93	9.27	4.62

Means followed by or sharing the same letters within a column are not significantly different at 5% level of significance; CV=coefficient of variation, LSD=least significant difference at 5%

3.4.5 Yield (ton/ha)

The result indicated that the effect of plant population and nitrogen fertilizer application showed a significant difference in pod fresh weight per plant. However, the interaction effect of plant population and nitrogen fertilizer rate did not show significant difference in pod fresh weight per plant. The yield was found to be significantly maximum with the treatment of 90kg ha^{-1} nitrogen (23.22ton ha^{-1}) (Table 5). Significantly higher yield was obtained with the spacing of 45cm × 30cm (24.62 ton ha^{-1}) (Table 5). Optimum plant population provides efficient utilization of resources thus increasing the growth characteristics of plant-like pod diameter, length and pod weight of plants which contributes to pod fresh weight yield (Abeykoon et al., 2011).

The total yield mainly depends upon the yield per plant and plant population. Therefore, closer spacing up to a particular limit produces higher yields due to more number of plants per hectare. Wider spacing leads to a lower number of plants per hectare and ultimately lower yields. The probability of producing higher green fruit yield per hectare with a higher density has been reported by Singh (1990). However, as a rule, all crops tend to extend yield as plant population density increased, but only up to a particular limit (AVRDC, 1990).

Table 6: Effect of different dose of nitrogen and spacing on yield of okra in 2018

Nitrogen (kg ha^{-1})	Yield ton/ha
N1 (60)	19.68^{c}
N2 (90)	23.22^{a}
N3 (120)	21.94^{b}
$LSD_{0.05}$	1.09
p-value	<0.0001***
Spacing (cm^{2})	
S1 (30× 30)	23.38^{a}
S2 (45× 30)	24.62^{a}
S3 (60× 30)	20.44^{c}
$LSD_{0.05}$	1.09
p-value	<0.0001***
Grand mean	21.62
CV%	5.05

Means followed by or sharing the same letters within a column are not significantly different at 5% level of significance; CV=coefficient of variation, LSD=least significant difference at 5%

3.5 Benefit-Cost Ratio

The Benefit-Cost (BC) ratio was significantly maximum for the treatment of 90 kg ha^{-1} nitrogen (2.23). The spacing of 45cm × 30cm had maximum BC ratio (2.68) which was statistically as par spacing with 30cm × 30cm (1.98). As plant density increases, cost of production automatically increased due to increased application of fertilizers and intercultural operations. The interaction effect of plant population and nitrogen fertilizer rate did not show a significant difference in BC ratio.

Table 7: BC ratio under different doses of nitrogen and spacing

Treatments	Benefit-Cost Ratio
Nitrogen (kg ha^{-1})	
N1 (60)	1.34^{c}
N2 (90)	2.23^{a}
N3 (120)	2.16^{b}
$LSD_{0.05}$	0.06
p-value	<0.0001***
Spacing (cm^{2})	
S1 (30× 30)	1.98^{a}
S2 (45× 30)	2.68^{a}
S3 (60× 30)	1.58^{b}
$LSD_{0.05}$	0.06
p-value	0.01**
Grand mean	1.15
CV%	5.04

Means followed by or sharing the same letters within a column are not significantly different at 5% level of significance; CV=coefficient of variation, LSD=least significant difference at 5%

4. CONCLUSION

In conclusion, all observed vegetative characteristics were found maximum for 120 kg ha^{-1} dose of nitrogen while they contrasted in case of spacing with plant height performing better in low spacing. Yield attributes; pod length, pod diameter and pod weight were better for 90 kg ha^{-1} dose of nitrogen spacing with 60×30 cm^{2}. The highest pod yield of okra and BC ratio was statistically best for nitrogen dose of 90 kg ha^{-1} and spacing 45cm×30cm suggesting an optimum supply of nitrogen under an optimum planting population contributes for the most profitable outcome. On the basis of both individual and combined effects of nitrogen and

spacing, it may be concluded from the results that the 90 kg Nha^{-1} with 45cm × 30cm spacing resulted in the highest yield and net income from okra var. Venus plus under the existing agro-climatic and plastic mulching conditions of Chitwan.

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REFERENCES

Abeykoon, A., R. Fonseka, S. Paththinige, K. Weerasinghe. 2011. Fertilizer requirement for densely planted okra [*Abelmoschus esculentus* (L.) Moench]. *Tropical Agricultural Research*, 21(3), 275. https://doi.org/10.4038/tar.v21i3.3301

AITC. 2017. Krishi Diary. Department of Agriculture, Agriculture Information and Training Center, Government of Nepal.

Ambare, T.P., V.S. Gonge, D.T. Deshmukh, A.D. Warade, B. Hameed. 2005. Effect of nitrogen on growth and yield of okra [*Abelmoschus esculentus* (L.) Moench] *J. Maharashtra Agriculture University*, 30(2), 217-218.

Amjad, M., M. Sultan, M.A. Anjum, C.M. Ayyub. 2002. Response of okra [*Abelmoschus esculentus* (L.) Moench] to various doses of N, P and different plant spacing. *Pakistan Journal of Research Science*, 13(1), 19-29.

Arora, S.K., P. Pratap, M. Pandita, I. Jalal. 1987. Production problems and their possible remedies in vegetable crops. *Indian Horticulture*, 32.

Attarde, S.B., S.D. Narkhede, R.P. Patil, S.T. Ingle. 2012. Effect of organic and inorganic fertilizers on growth and nutrient content of [*Abelmoschus esculentus* (L.) Moench], 4(10), 137-140.

AVRDC. 1990. Vegetable-Production Training Manual, 447. Asian Vegetable Research and Development Center, Shanhua, Taiwan.

Bajpai, V.P., A.A. Khan, S. Kumar, P. Singh, C.B. Singh. 2004. Effect of spacing and sowing dates on growth and seed quality of okra [*Abelmoschus esculentus* (L.) Moench] Farm sci. 113(2), 116-117.

Balasubraniyan, P., S.P. Palaniappan. 2004. Principles and Practices of Agronomy, Agrobios, Jodhpur, India, 185.

Bin-Ishaq, M.S. 2009. Effect of plant density and nitrogen fertilization on vegetative growth, seed yield and quality of okra plants. Alandalus Journal for Social and Applied Science, 2(4), 43-57.

Bose, T.K., M.G. Som. 1986. Vegetable crops in India. Naya prokash, pub. culcutta. 606.

Ekwu, L.G., G.N. Nwokwu. 2012. Effect of plant spacing and planting date on the growth and yield of okra [*Abelmoschus esculentus* (L.) Moench] in Abakaliki. International Journal of Agriculture and Rural Development, 15(2), 1041-1048.

Fagaria, M.S., P.S. Arya, A.K. Singh. 1993. Effect of sowing dates and nitrogen levels on seed yield in okra [*Abelmoschus esculentus* (L.) Moench]. Haryana Journal Horticulture Science, 22(1), 66-69.

Firoz, Z.A. 2009. Impact of nitrogen and phosphorus on the growth and yield of okra [*Abelmoschus esculentus* (L.) Moench] in hill slope condition. Bangladesh Journal of Agriculture Research, 34(4), 713-722.

Futuless, K.N., H.W. Bagale. 2007. Effects of different levels of nitrogen fertilizer on the growth and yield of amaranthus (*Amaranthus cruentus*) in Mubi, Adamawa State, Nigeria. Proceeding Horticultural Society of Nigeria, held at Adamawa State University, Mubi, Nigeria. 26th – 30th Oct. 2008, Adamawa State University, Mubi, Nigeria.

Ghoneim, I.M. 2000. Effect of okra plants decapitation under various nitrogen levels on growth, flowering, green pod yield, and seed production. Adv. Agric. Res, 5(2), 1405-1424.

Harischand, R., M.M. Khan, P.K. Singh. 2013. Effect of spacing and cultivars on growth and yield of okra (*Abelmoschus esculentus* L. Moench). Asian Journal of Horticulture, 8(2), 507-511.

Khan, A.R., R.C. Jaiswal. 1988. Effect of nitrogen, spacing and green fruit pickings on the seed production of okra [*Abelmoschus esculentus* (L.) Moench] Vegetable Science, 15(5), 8-14.

MoAD. 2015-2016. Statistical Information on Nepalese Agriculture. Singha Durbar Kathmandu, Nepal: Monitoring, Evaluation and Statistics Division, Government of Nepal.

Pandy, U.C., V.P. Manocha. 1989. Economic aspects of okra seed production. Agricultural Science Digest Karmal, 9(2), 91-93.

Paththinige, S.S., P.S.G. Upashantha, R.M.R. Banda, R.M. Fonseka. 2008. Effect of plant spacing on yield and fruit characteristics of okra [*Abelmoschus esculentus* (L.) Moench]. Tropical Agricultural Research, 20, 336-342.

Sajjan, A.S., M. Shekhargouda, V.P. Badanur. 2002. Influence of date of sowing, spacing and levels of nitrogen on yield attributes and seed yield in okra. Karnataka Journal of Agricultural Science, 15, 267-274.

Salazar, F., M. Alfaro, S. Ledgard, S. Iraira, N. Teuber, L. Ramirez. 2011. Effect of the stocking rate and land slope on nitrogen losses to water on a grazed pasture of southern Chile. Journal of Soil Science and Plant Nutrition, 11, 98-109.

Singh, B.P. 1990. Effect of spacing on okra. Indian Journal of Agronomy, 35, 439- 441.

Thavaprakash, N., K. Velayudam. 2007. Effect of crop geometry, Intercropping systems and INM practices on nutrient uptake. Asian Journal of Agricultural Research, 1, 10-16.

Wu, Y.B.A., N.O. Kahn, J.B. Maness, R.W. Solie, R.W. Whitney, K.E. Conway. 2003. Densely planted okra for destructive harvest: Effects on plant architecture. Horticulture Science, 38(7), 1365-1369.