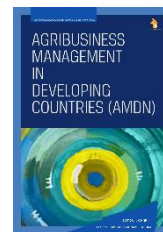




E-ISSN: 2990-9309 (Online)
***CODEN: AMDND7**

Agribusiness Management In Developing Nations (AMDN)

DOI: <http://doi.org/10.26480/amdn.02.2024.72.77>



RESEARCH ARTICLE

EFFECT OF SPACING ON GROWTH AND PRODUCTION OF OKRA IN MAHOTTARI, NEPAL

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ARTICLE DETAILS

Article History:

Received 23 August 2024
Revised 18 September 2024
Accepted 11 October 2024
Available online 14 October 2024

ABSTRACT

Inconvenient spacing is one of the major problems in okra production, due to which the yield of okra is much lesser than its production potential. Hence, field research on the topic of "Effect of spacing on growth and production of okra in Mahottari, Nepal" was conducted at Matihani municipality of Mahottari district during the spring season of 2022. Research was carried out to evaluate the growth and reproductive character of okra. Research was conducted on RCBD research design with 5 replications and 4 treatments viz. 60cm*30cm spacing, 50cm*30cm spacing, 40cm*30cm spacing and 30cm*30cm spacing. The findings of the research revealed that the spacing of 60cm*30cm result in the highest plant height and maximum number of leaves per plant followed by the spacing of 50cm*30cm and the lowest plant height and minimum number of leaves per plant resulted in the spacing of 30cm*30 cm. Fruit length and fruit weight were found to be highest in the spacing of 60cm*30cm followed by the spacing of 50cm*30cm and lowest fruit length and fruit weight found in the spacing of 30cm*30cm. The highest production per plant (432.00g) was reported on the spacing of 50cm*30cm followed by the spacing of 60cm*30cm, whose production per plant was 415.50g but the lowest production per plant (298.62g) was reported in the spacing of 30cm*30cm. The spacing of 30cm*30cm resulted from a maximum yield i.e. 33.18 Mt/ha, followed by the yield of spacing 50cm*30cm which is 28.80 Mt/ha, and the lowest yield (23.94 Mt/ha) was resulted from the spacing of 60cm*30cm. The spacing of 50cm*30cm was found most suitable for okra production with desirable fruit parameters and higher production however higher plant height and several leaves were found on spacing of 60cm*30cm.

KEYWORDS

Okra, Spacing, reproductive character

1. INTRODUCTION

The okra (*Abelmoschus esculentus*) is one of the most important summer vegetable crops grown in Nepal at subsistence to commercial scale. It is also known as a lady's finger. It belongs to the family Malvaceae (Maurya et al., 2013). Okra originated in Asia and Africa (Thomson and Kelly, 1979). It is widely distributed and cultivated in the tropics, sun-tropics and warmer portions of the temperate region of the world on a varying scale (Kochhar, 1986). The chromosome number of okra varies greatly, with the diploid ranging from 2n=66 to 144 (Lamont, 1999). Okra is a multipurpose crop due to its various uses of fresh leaves, buds, flowers, pods, stems, and seeds (Mihretu et al., 2014). Its fruit is called a capsule. The immature fruits are used for making soup and other sauces that are eaten with cereals or tubers (Yadav and Dhanker, 2002). Its seed could be used as a non-caffeinated substitute for coffee. Okra seeds may be roasted and ground to form a caffeine-free substitute for coffee (Calisir and Yildiz, 2005). Other than immature fruits and seeds, dried vegetative parts could be used as fuel, and fiber of okra plants could be used as material for making paper (Lamont, 1999). Okra is rich in dietary fiber, minerals, vitamins, antioxidants, and folate. Okra is rich in several vitamins, minerals, and nutrients (Gemede et al., 2015).

Spacing had a significant effect on yield and other growth factor. The total yield of okra depends upon the yield per plant and plant population per unit area (Paththinige et al., 2008). Convenient spacing could utilize

resource efficiently and could help increase productivity.

Okra is one of the leading vegetables in the world, mostly in Asian and African regions. India is the largest okra producer in the world, with 6.18 million Mt. followed by Nigeria with 1.82 million Mt (FAOSTAT, 2020). In Nepal, okra cultivation is practiced in a 9,337 ha area and production is 103,353 Mt with a yield of 11.07 Mt/ha.

Okra productivity in Nepal is just 11 tons per hectare (MoALD, 2021), which is significantly lower than the production capacity of the okra type grown in Nepal. Arka Anamika has a production potential of 24 to 32 tons per hectare, while Parbati has a production potential of 12 to 16 tons per hectare (Krishi Diary, 2078). There is lower productivity of okra in Mahottari than national productivity (MoALD, 2021). With lesser spacing, resources for plant become limited and yield decreases and with higher spacing, plant population per unit area and yield decreases (Weiner, 1990). Farmer has no proper knowledge about spacing. Farmer use inconvenient spacing and conventional farming practices. Irrational fertilizer usage; insect pests, diseases, and weeds management are ineffective; technology and skilled manpower shortage and there have been very few site-based researches on proper spacing; these are some other problems. Farmers commonly believe that having a larger number of plants will result in a higher yield. As a result, they keep a fairly close distance between them. This causes the plants to absorb insufficient nutrients and interferes with the okra plants' light requirements. The yield

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Website:
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DOI:
[10.26480/amdn.02.2024.72.77](http://doi.org/10.26480/amdn.02.2024.72.77)

of okra is reduced as a result of all of these factors.

Total yield depends upon the yield per plant and plant population (Paththinige et al., 2008). Convenient spacing could utilize resources efficiently and could help increase productivity. Proper spacing helps farmers in intercultural operations like weeding. Nepal is an agricultural country. More than 55% populations are involved in agriculture. Still, we have to import huge quantities of agricultural commodities from India and other countries. The main cause for it; is low production of commodities. Production can be increased in two ways i.e. from vertical expansion and horizontal expansion. In the present scenario of increasing population, increasing production by vertical expansion is easier than by horizontal expansion due to the limitation of land. Due to low productivity, there is a high scope to increase production by vertical expansion by shifting traditional way of farming to modern way. Appropriate spacing could be one of the best options to increase the productivity of okra. This research will give the right spacing at local conditions, as spacing is one of the primary governing elements for the overall yield and quality of okra produced. Farmers believe that having a larger number of plants will result in a higher yield. As a result, farmers must be educated on the importance of convenient spacing so that they can get the most out of the limited resources available to them.

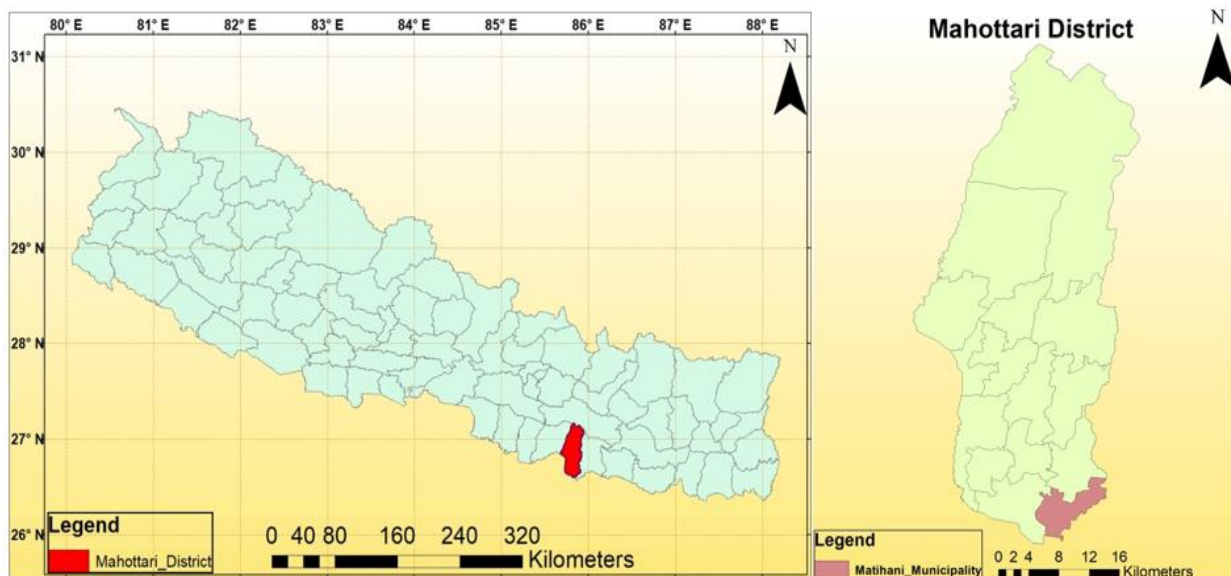
Spacing is one of the characteristics that may influence the horticultural character, fruit character and productivity components of okra. With increasing plant population, yield per unit area increases until certain limit, beyond which resources for plant become limited and yield decreases (Weiner, 1990). Plant growth and yield are influenced by intra and inter row spacing, hence optimum population density is essential for improved yield in okra. Krishi Diary recommends 50 cm*30 cm plant spacing for okra production. The quantity and weight of fruits per plant, as well as the number of okra vegetative branches per plant, fell dramatically as population density increased (Ekwu et al., 2010). To accomplish the yield quality criteria, a spacing of 45 cm*45 cm was adopted (Paththinige et al., 2008). However, it can be presumed that densely planted okra, (i.e. at 45 cm x 45 cm spacing), may demand large quantities of fertilizers when calculated on the per plant basis. The lowest planting density (37,000 plants/ha) resulted in a maximum number of matured pods per plant, the highest weight of matured pods, and the highest seed yield per plant. According to Singh (1990), the largest average weight of single fruit and fruit length were obtained at the widest spacing (50 cm x 40 cm). Okra plants with the widest spacing had the largest fruit

length, weight, number, and yield per plant (Ali, 1999). However, the highest fruit yields per hectare were at closest spacing indicated that the closer spacing between plants taller was the plant height. However, the wider spacing enhanced number of branches per plant (El Mazny et al., 1990). According to the finding of plant spacing had a significant effect on the number of days to 50% anthesis (Ekwu et al., 2010). They indicated that the number of days to 50% anthesis was shortest at 50 cm x 75 cm (widest plant spacing) while it was longest at 50 cm x 25 cm. Plant height increased as the space between plants increased from 50 cm x 25 cm to 50 cm x 50 cm, after which plant height decreased. As the plant spacing rose from 50 cm x 25 cm to 50 cm x 75 cm, the number of branches, leaves, and days to 50% anthesis decreased. The widest plant spacing consistently gave the lowest values in all the vegetative parameters measured except plant height. Highest plant height was observed in wider spacing (Aniketvilas et al., 2016). The study number of branches and number of leaves per plant significantly increased as the plant density decreased (Bin-Ishaq, 2009). The study reported that the lowest planting density (37000 plants/ha) resulted in maximum number of matured pods per plant and highest weight of matured pods (Amjad et al., 2002). The length and weight of pods was highest at the closest plant spacing (50 cm x 25 cm). As plant spacing grew from 50 cm x 25 cm to 50 cm x 75 cm, the weight of okra pods dropped. However, the largest weight of pods was generated at a plant spacing of 50 cm x 25 cm, whereas 50 cm x 75 cm produced the least (Ekwu et al., 2010). With tighter spacing, plant height at flowering rose, whereas with wider spacing, plant height dropped (Raghav, 1996). Days needed for the initial blooming were not significantly impacted by plant spacing (Amjad et al., 2002). On the other hand, plant spacing significantly influenced pod length, with the highest occurring at the widest spacing (45 cm). As the distance between plants rose, more green pods were produced per plant, according to a comparison of plant spacing. Plants obtain more nutrients and experience lateral growth as a result of wider spacing, resulting in an increase in the amount of fruits per plant.

3. MATERIALS AND METHODS

3.1 Research Site

The research conducted at Matihani municipality ward number 6 in Mahottari district. The research site lies at 5 KM south east from Jaleshwar, Mahottari. It is located at an elevation of 67 masl (219.8 feet). The latitude and longitude of research site is 26.82° north and 85.84° east.



Map of Nepal showing Mahottari district

Map of Mahottari district showing Matihani Municipality

Figure 1: Map of Nepal showing research site

3.2 Research Design

Research was conducted in Randomly Complete Blocking Design (RCBD) experimental design with 4 treatments and 5 replications. So, there were total 20 plots in the research field.

3.3 Details of the experiment

On the research, following treatments were used.

Table 1: Treatments of experiment

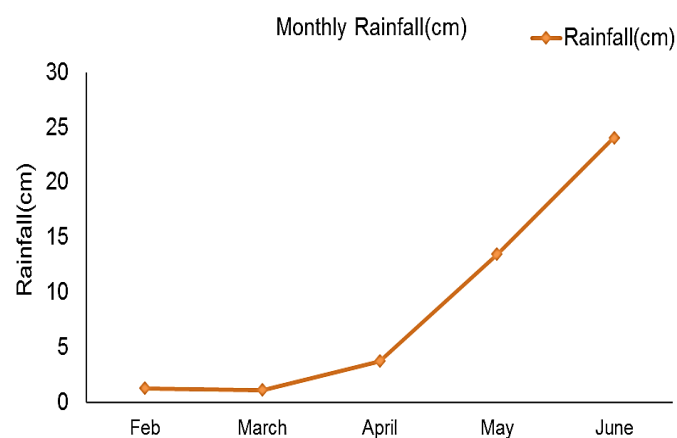
T1	60cm*30cm spacing
T2	50cm*30cm spacing
T3	40cm*30cm spacing
T4	30cm*30cm spacing

3.4 Soil Report

Soil of the research field was tested on Soil and Fertilizer Testing Laboratory, Jhumka, Province 1. Following report got from testing:

Table 2: Soil testing report	
Soil type	Clay loam
Sand	28%
Slit	42%
Clay	30%
Soil ph	7.2
Organic matter	1%
Nitrogen	0.05%
Phosphorus	194 Kg/ha
Potash	66.5 Kg/ha
Boron	0.001 PPM
Zinc	0.98 PPM

3.5 Weather report



3.7 Layout of the Experiment

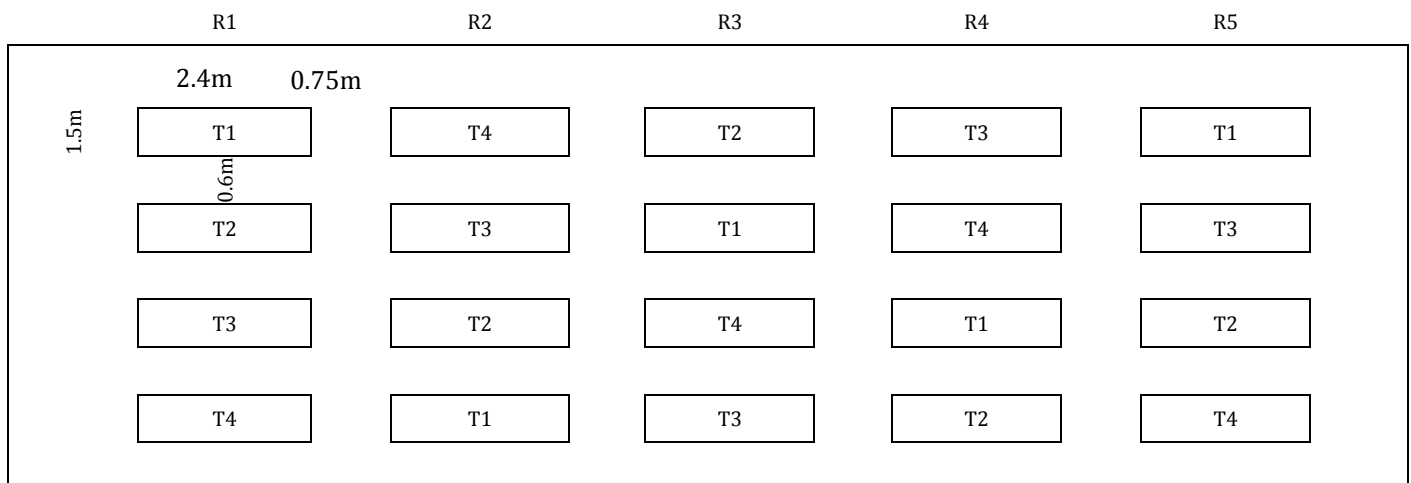


Figure 3: Layout of research field

3.8 Data Collection

Data were collected for following character:

3.8.1 Plant Height

Total 5 plants selected as sample plant from each plot. Height of each plant measured and recorded on 20 DAS, 35 DAS, 50 DAS and 65 DAS.

3.8.2 Number of Leaves

From selected 5 samples plants, number of leaves counted at 20 DAS, 35 DAS, 50 DAS and 65 DAS and recorded.

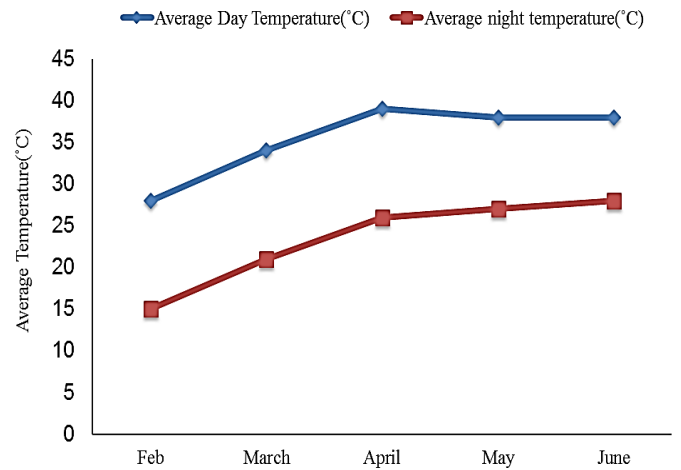


Figure 2: Rainfall and monthly average temperature of research site

3.6 Activities in the field

Soil sample taken at Falgun 18, 2078 for soil testing. On Falgun 27, 2078, the land was prepared by deep ploughing following the mixing of FYM. Plot size of 2.4m length and 1.5m width was prepared. Spacing between plots was 0.60m and spacing between replication was 0.75m. This layout was created at Chaitra 18, 2078. Flooding irrigation completed at Chaitra 20, 2078. Chemical fertilizer (Urea, DAP, and MOP) was used in the study field at Chaitra 21, 2078. Okra was sown on Chaitra 23, 2078. After germination, watering was done on alternate days. At Baishakh 5, 2079, 5 samples were taken from each plot. The first data was recorded on Baishakh 13, 2079, when the plant's height was measured and the number of leaves per plant was tallied. Flooding irrigation had been completed on Baishakh 19, 2079, and the remaining dose of Urea had been put to the area. On Baishakh 24, 2079, a bio-insecticide called Multineem was used in the field to combat various insects on the plants and to manage weed, manual hand weeding method was used. The second set of data was collected on Baishakh 28, 2079, and included measurements of plant height and the number of leaves per plant. On alternating days beginning on Jestha 6, 2079, different parameter data (fruit length, fruit weight, number of fruits per plant, production per plant, and yield) were recorded.

3.8.3 Fruit Length

Fruits harvested on alternate days, after weighing harvested fruits from sample plants, the length of each fruits measured and recorded.

3.8.4 Fruit Weight

Harvested fruits weight measure with electronic weighing machine after each harvesting and recorded.

3.8.5 Number of Fruits

Number of fruits harvested on each harvesting recorded and after last

harvesting, total number of fruits calculated and recorded.

Weight of fruits on each harvesting measured and after last harvesting total production per plant calculated by the addition and recorded.

3.8.6 Yield

The average production per plant calculated and multiplied by plant density to obtain yield and recorded.

3.9 Data Analysis

Data obtained from research was arranged systematically treatment wise on the basis of various parameter chosen. R-studio and MS-Excel had used as data analysis tools. Mean comparison was done by LSD test at 5% level of significance.

4. RESULTS AND DISCUSSION

4.1 Plant Height

The results showed that the effect of different spacing on plant height was significant at all growth stages except 20 days of sowing (Table 4). The non-significant result in height of the plant at 20 DAS, which might be due to less nutrient requirement at initial stage for growth and development. At 35 DAS, plant height was the highest (36.12 cm) in the spacing of 60cm*30cm and the least (26.72 cm) in the spacing of 30cm*30cm. Plant height in spacing 60cm*30cm (36.12cm) is statistically similar with the plant height of spacing 50cm*30cm (34.32cm) and 40cm*30cm(29.84cm). A similar pattern was observed at 50 DAS and 65 DAS (Table 4). Spacing can have great effect on plant height. The increase in plant height by increasing spacing may be due to the optimum availability of nutrient and moisture. Similar results observed by (Aniketvilas et al., 2016).

Table 3: Effect of spacing on plant height at Mahottari, Nepal, 2022

Treatments	Plant height(cm)			
	20 DAS	35 DAS	50 DAS	65 DAS
T1 (60cm*30cm spacing)	10.44	36.12 ^a	60.00 ^a	112.32 ^a
T2 (50cm*30cm spacing)	9.64	34.32 ^a	57.32 ^a	105.44 ^{ab}
T3 (40cm*30cm spacing)	9.16	29.84 ^{ab}	51.84 ^{ab}	94.48 ^{bc}
T4 (30cm*30cm spacing)	8.92	26.72 ^b	48.72 ^b	88.96 ^c
SEM(±)	0.28	1.11	1.35	2.66
LSD(α=0.05)		6.86	8.29	16.41
CV(%)	13.08	15.69	11.05	11.87
F test(α=0.05)	NS	*	*	*
Grand Mean	9.54	31.75	54.47	100.3

Note: SEM(±), Standard Error of mean; CV, Coefficient of variation; LSD, Least significant difference; NS, non significant; Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.05 level of significance; '*' significant at 0.05 level of Significance; '**' significant at 0.01 level of Significance

4.2 Number of leaves

The results showed that the effect of different spacing on number of leaves was significant at all growth stages except 20 days of sowing (Table 5). The non-significant result regarding the number of leaves at 20 DAS signified that there was no variation among the plants for number of leaves at initial stage, which might be due to less nutrient requirement at initial stage for

growth and development. At 35 DAS, number of leaves were the highest (24.72) in the spacing of 60cm*30cm and the least (17.92) in the spacing of 30cm*30cm. Number of leaves in spacing 60cm*30cm (24.72) is statistically similar with the number of leaves of spacing 50cm*30cm (20.24). A similar pattern was observed at 50 DAS and 65 DAS (Table 5). Spacing have great effect on the number of leaves.

Table 4: Effect of spacing on number of leaves at Mahottari, Nepal, 2022

Treatments	Number of leaves			
	20 DAS	35 DAS	50 DAS	65 DAS
T1 (60cm*30cm spacing)	5.93	24.72 ^a	45.36 ^a	68.76 ^a
T2 (50cm*30cm spacing)	5.87	20.24 ^{ab}	39.64 ^{ab}	61.52 ^{ab}
T3 (40cm*30cm spacing)	5.80	19.20 ^b	37.44 ^b	57.88 ^b
T4 (30cm*30cm spacing)	5.53	17.92 ^b	33.16 ^b	53.32 ^b
SEM(±)	0.08	0.78	1.19	1.66
LSD(α=0.05)		4.81	7.33	10.26
CV(%)	6.25	16.99	13.68	12.33
F test(α=0.05)	NS	*	*	*
Grand Mean	5.783	20.52	38.9	60.37

Note: SEM(±), Standard Error of mean; CV, Coefficient of variation; LSD, Least significant difference; NS, non significant; Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.05 level of significance; '*' significant at 0.05 level of Significance; '**' significant at 0.01 level of Significance

4.3 Fruit Length

The results showed that the effect of different spacing on the fruit length was significant (Table 8). Fruit length was the highest (13.70 cm) in the spacing of 60cm*30cm and the least (10.90 cm) in the spacing of 30cm*30cm. Fruit length in spacing 60cm*30cm (13.70 cm) is statistically

similar with the fruit length of spacing 50cm*30cm (13.00 cm) and spacing 40cm*30cm (11.94 cm) . Fruit length of spacing 30cm*30cm was the lowest(10.90 cm) which is statistically similar with spacing of 40cm*30cm(11.94 cm). Wider spacing was found to have higher fruit length; which might be due to less plant competition for nutrient and moisture . Spacing have great effect on fruit length (Ali, 1999).

Table 5: Effect of spacing on fruit length at Mahottari, Nepal, 2022

Treatments	Fruit length (cm)
T1 (60cm*30cm spacing)	13.70 ^a
T2 (50cm*30cm spacing)	13.00 ^a
T3 (40cm*30cm spacing)	11.94 ^{ab}
T4 (30cm*30cm spacing)	10.90 ^b
SEM(±)	0.31
LSD(α=0.05)	1.90
CV(%)	11.12
F test(α=0.05)	*
Grand Mean	12.39

Note: SEM(±), Standard Error of mean; CV, Coefficient of variation; LSD, Least significant difference; NS, non significant; Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.05 level of significance; '*' significant at 0.05 level of Significance; '**' significant at 0.01 level of Significance

4.4 Fruit weight

The results showed that the effect of different spacing on the fruit weight was significant (Table 9). Fruit weight was the highest (20.43 gram) in the spacing of 60cm*30cm and the least (14.98 gram) in the spacing of 30cm*30cm. Fruit weight in spacing 60cm*30cm (20.43 gram) is statistically similar with the fruit weight of spacing 50cm*30cm (19.11 gm) and spacing . Fruit weight of spacing 30cm*30cm was the lowest (14.98 gram) which is statistically similar with spacing of 40cm*30cm (16.55 gram). The analysis also discovered, wider spacing was found to have higher fruit weight; which might be due to less plant competition for nutrients and moisture. Spacing have great effect on fruit weight (Ali, 1999).

Table 6: Effect of spacing on fruit weight at Mahottari, Nepal, 2022

Treatments	Fruit weight (gram)
T1 (60cm*30cm spacing)	20.43 ^a
T2 (50cm*30cm spacing)	19.11 ^{ab}
T3 (40cm*30cm spacing)	16.55 ^{bc}
T4 (30cm*30cm spacing)	14.98 ^c
SEM(±)	0.43
LSD(α=0.05)	2.65
CV(%)	10.80
F test(α=0.05)	**
Grand Mean	17.77

Note: SEM(±), Standard Error of mean; CV, Coefficient of variation; LSD, Least significant difference; NS, non significant; Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.05 level of significance; '*' significant at 0.05 level of Significance; '**' significant at 0.01 level of Significance

4.5 Number of Fruits

The results showed that the effect of different spacing on the number of fruits was non-significant (Table 10). Numerically number of fruits was the highest (22.71) in the spacing of 50cm*30cm and the least (20.47) in the spacing of 40cm*30cm. Number of fruits in spacing 60cm*30cm is 20.47, spacing 50cm*30cm is 22.71, spacing 40cm*30cm is 19.47 and spacing 30cm*30cm is 20.06. The study discovered, wider spacing was found to have higher number of fruits; which is in contrast with the finding of research; which might be due weather factors (Ali, 1999).

Table 7: Effect of spacing on number of fruits at Mahottari, Nepal, 2022

Treatments	Number of fruits
T1 (60cm*30cm spacing)	20.47
T2 (50cm*30cm spacing)	22.71
T3 (40cm*30cm spacing)	19.41
T4 (30cm*30cm spacing)	20.06
SEM(±)	0.51
LSD(α=0.05)	
CV (%)	10.94
F test(α=0.05)	NS
Grand Mean	20.66

Note: SEM(±), Standard Error of mean; CV, Coefficient of variation; LSD, Least significant difference; NS, non significant; Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.05 level of significance; '*' significant at 0.05 level of Significance; '**' significant at 0.01 level of Significance

4.6 Production Per Plant

The results showed that the effect of different spacing on the production per plant was significant (Table 11). Production per plant was the highest (432.00 gram) in the spacing of 50cm*30cm and the least (298.62 gram) in the spacing of 30cm*30cm. Production per plant in spacing 50cm*30cm (432.00 gram) is statistically similar with the production per plant of spacing 60cm*30cm (415.50 gram). Production per plant of spacing 30cm*30cm was the lowest(298.62 gram) which is statistically similar with spacing of 40cm*30cm(320.40 gram). Ali (1999) discovered, wider spacing was found to have higher production per plant which is similar to the outcome of our research; which might be due to availability of optimum nutrient and moisture. This show, spacing have great effect on production per plant.

Table 8: Effect of spacing on production per plant at Mahottari, Nepal, 2022

Treatments	Production per plant (gram)
T1 (60cm*30cm spacing)	415.50 ^a
T2 (50cm*30cm spacing)	432.00 ^a
T3 (40cm*30cm spacing)	320.40 ^b
T4 (30cm*30cm spacing)	298.62 ^b
SEM(±)	10.73
LSD(α=0.05)	66.14
CV(%)	13.09
F test(α=0.05)	**
Grand Mean	366.63

Note: SEM (±), Standard Error of mean; CV, Coefficient of variation; LSD, Least significant difference; NS, non significant; Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.05 level of significance; '*' significant at 0.05 level of Significance; '**' significant at 0.01 level of Significance

4.7 Yield

The results showed that the effect of different spacing on the yield was significant (Table 12). Yield was the highest (28.80 Mt/ha) in the spacing of 50cm*30cm and the least (23.94 Mt/ha) in the spacing of 60cm*30cm. Yield in spacing 50cm*30cm (28.80 Mt/ha) is statistically similar with the yield of spacing 30cm*30cm (33.18 Mt/ha). Yield of spacing 60cm*30cm was the lowest (23.94 Mt/ha) which is statistically similar with yield of spacing 40cm*30cm (26.70 Mt/ha). According to when spacing shrank, yield increased; which iss in contrast with the outcome of our research; which might be due to higher production per plant in spacing 50cm*30cm. This show, spacing can have great effect on production per plant (Weiner, 1990).

Table 9: Effect of spacing on yield at Mahottari, Nepal, 2022

Treatments	Yield(Mt/ha)
T1 (60cm*30cm spacing)	23.94 ^c
T2 (50cm*30cm spacing)	28.80 ^{ab}
T3 (40cm*30cm spacing)	26.70 ^{bc}
T4 (30cm*30cm spacing)	33.18 ^a
SEM(±)	0.78
LSD(α=0.05)	4.80
CV(%)	12.37
F test(α=0.05)	**
Grand Mean	28.16

Note: SEM(±), Standard Error of mean; CV, Coefficient of variation; LSD, Least significant difference; NS, non-significant; Means in the column with same letter (s) in superscript indicate no significant difference between treatments at 0.05 level of significance; '*' significant at 0.05 level of Significance; '**' significant at 0.01 level of Significance

5. CONCLUSION

The different spacing used as treatment in this research were found to have significant result in different parameters. Plant height was increasing with wider spacing except for 20 DAS. Similar results had been obtained for number leaves. Fruit length and fruit weight has also increased with increasing spacing. There was no significant difference in number of fruit per plant due to plant spacing. Production per plant was found highest in 50cm*30cm spacing and lowest in 30cm*30cm spacing however highest yield was obtained in 30cm*30cm spacing but yield of 50cm*30cm also statistically similar with highest yield and lowest yield reported on spacing 60cm*30cm. Most of the growth and reproductive parameters were higher in wider spacing except for number of fruits, production per plant and yield. 50cm*30cm spacing was found to be best for yield by considering it's result about all the parameter concerns. so it is recommended for farmer to use spacing of 50cm*30cm.

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