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Effect of Spacing and Ratooning on Growth and Yield of Okra (*Abelmoschus esculentus* L. Moench) Var. Lal Bhendi No. 533

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was laid down in Factorial Randomized Block Design (FRBD) with nine treatment combinations and four replications during year 2023. The experiment consists of two factors, factor A: Spacings (**S_1-** 60 cm x 30 cm, **S_2-** 90 cm x 30 cm and **S_3-** 120 cm x 30 cm) and factor B: Stages of ratooning (**R_1-** Ratooning at 90 DAS, **R_2-** Ratooning at 105 DAS and **R_3-** No ratooning). Among the three spacings, 120 cm x 30 cm (S_3) revealed higher values for growth parameters such as number of leaves (33.96), nodes (17.25), branches (1.42), yield parameters like number of fruits (24.37), yield per plant (304.31 g). The highest yield per hectare (15.07 t/ha) was obtained under closer spacing S_1 - 60 cm x 30 cm. Among various ratooning treatments, number of fruits (25.33), yield per plant (315.98 g) and total yield (12.51 t/ha) was significantly higher in control (R_3-No ratooning), the number of fruits (22.93), yield per plant (277.54 g) and total yield (10.99 t/ha) was greater in R_1 than R_2. Among ratooning treatment, R_1 was better than R_2 in terms of growth and yield characters. In interaction, spacing of 120 cm x 30 cm without ratooning (S_3R_3) was found better with respect to growth and yield of okra, whereas overall yield per hectare (16.53 t/ha) was greater in (S_1R_3) spacing 60 cm x 30 cm without ratooning. The data recorded in present investigation revealed that spacing and ratooning influenced the growth and yield parameters of okra. Thus, considering the yield of okra, spacing of 60 cm x 30 cm without ratooning found to be beneficial for Konkan agro-climatic conditions.

Keywords: Lal bhendi; spacing; ratooning; growth; yield; okra.

1. INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is one of the important vegetable growing in India having chromosome no. 2n = 120 and belonging to family Malvaceae (Keisham et al., 2015). India is the largest producer of okra in the world. In 2021, world production of okra was 10.8 million tonnes (FAO 2022). India produces 60% of the total okra production with Nigeria and Mali as secondary producers (FAO 2022). Andhra Pradesh, West Bengal, Bihar, Gujarat, Odisha, Jharkhand and Maharashtra are the leading okra producing states in India (NHB 2020). Reddish purple pigmentation in red fruited okra, is mainly due to the accumulation of anthocyanin which present in combination with chlorophyll. In general, unfertilized ovaries of red okra are green in colour. Two days after fertilization, sparse red colour development started and it is increases subsequently which turns the fruits dark reddish purple at horticulture maturity (Karmarkar et al., 2022). The improper plant spacing may causes the reduction of yield. The optimum plant density ensures the plants to grow uniformly and properly through optimum utilization of moisture, nutrients, light and thus enables to harvest maximum potential yield (Firoz et al., 2007). Ratooning gives opportunity to enhance agricultural sustainability by optimizing resources. It can also reduce the cost of cultivation by avoiding repeated land preparation and sowing of the crop.

2. MATERIALS AND METHODS

The experiment was conducted at College of Horticulture, Dapoli, Dist.- Ratnagiri during year 2023. It's geological position on world map is 17°45" North Longitude and 73°12" East longitude. The experiment was laid down in Factorial Randomized Block Design (FRBD) with nine treatment combinations and four replications. The experiment consists of two factors, factor A: Spacings (**S_1-** 60 cm x 30 cm, **S_2-** 90 cm x 30 cm and **S_3-** 120 cm x 30 cm) and factor B: Stages of ratooning (**R_1-** Ratooning at 90 DAS, **R_2-** Ratooning at 105 DAS and **R_3-** No ratooning).

Treatment combination	Treatment details
S_1R_1	Spacing 60 cm x 30 cm with ratooning at 90 DAS
S_1R_2	Spacing 60 cm x 30 cm with ratooning at 105 DAS
S_1R_3	Spacing 60 cm x 30 cm with no ratooning
S_2R_1	Spacing 90 cm x 30 cm with ratooning at 90 DAS
S_2R_2	Spacing 90 cm x 30 cm with ratooning at 105 DAS
S_2R_3	Spacing 90 cm x 30 cm with no ratooning
S_3R_1	Spacing 120 cm x 30 cm with ratooning at 90 DAS
S_3R_2	Spacing 120 cm x 30 cm with ratooning at 105 DAS
S_3R_3	Spacing 120 cm x 30 cm with no ratooning

Ten plants were randomly selected and tagged in each treatment from four replications and observations recorded on different growth parameters and yield parameters. Gap filling, thinning and weeding was carried out as per the requirement. Recommended dose of fertilizer NPK 100:50:50 kg/ha was applied through organic manures in the form of FYM @ 10 t/ha and inorganic fertilizers in the form of 18:18:10, 19:19:19 and urea. Irrigation was given daily for 1 hour through micro jet sprinklers after rainy season.

3. RESULTS AND DISCUSSION

The data pertaining to effect spacing and ratooning on various growth parameters at 90 DAS are presented in Table 1.

Plant height (cm): The tallest plants (145.72 cm) were observed in S_1 (60 cm x 30 cm), while the shortest plants (127.37 cm) were observed in S_3 (120 cm x 30 cm). The plant population per unit area was more in closer spacing (S_1) than wider spacing (S_3). Overcrowding of plants create shading effect on each other which reduced light access to plants which might led to etiolation where plants grew taller due to competition to receive ample sunlight. Same results is also reported by Moniruzzaman et al*.,* (2007) and Maurya et al*.,* (2013) in okra. Effect of ratooning and interaction effect of spacing and ratooning on plant height was non-significant as the ratooning was done at 90 DAS and 105 DAS.

Number of leaves: The maximum number of leaves (33.96) were recorded in S_3 (120 cm x 30 cm) and the minimum leaves (32.56) were recorded in S_1 (60 cm x 30 cm). The reduced competition for light and other resources as well as reduced overlapping from adjacent okra plants within the population could have enabled the plants in wider spacing to utilize its energy for maximum production of leaves. Sharma et al*.,* (2012) also reported significantly more number of leaves in wider spacing of okra. The impact of ratooning as well as interaction effect of spacing and ratooning on number of leaves was non-significant as the ratooning was done at 90 DAS and 105 DAS.

Number of branches: Data on effect of spacing on number of branches per plants was significant. The maximum number of branches (1.42) were observed in S_3 (120 cm x 30 cm), while minimum branches (1.21) were observed in S_1 (60 cm x 30 cm). Closer spacing might increased competition among adjoining plants for available nutrients, water as well as for aerial space for canopy spread which might have prevented production of profuse branching in closer spacing than wider spacing. Agba et al., (2011) and Ijoyah et al., (2010) also reported greater branch number in wider spacing compared to reduced spacing in okra. The impact of ratooning as well as interaction effect of spacing and ratooning on number of branches was non-significant as the ratooning was done at 90 DAS and 105 DAS.

Stem girth: Maximum girth (2.37 cm) was recorded in S_3 (120 cm x 30 cm) which was notably better over other treatments. Minimum girth (2.12 cm) was observed in S_1 (60 cm x 30 cm). The availability of more nutrients, moisture and light in the wider plant spacing possibly resulted in better accumulation of more carbohydrates due to more photosynthesis which might have increased stem girth. Contrastingly, in closer plant spacing, the competition between plants for nutrients, light and moisture which adversely affected in plant health. Thus, the stem girth of plants in wider spacing was thicker than other spacings. These results are analogous with results presented by Ghadge, (2014) and Madisa et al*.,* (2015) in okra. The impact of ratooning as well as interaction effect of spacing and ratooning on stem girth at 90 DAS was non-significant as the ratooning was done at 90 DAS and 105 DAS.

Number of Nodes: Influence of spacing on number of nodes on plants was significant. Maximum nodes (17.28) were noted in S_3 (120 cm x 30 cm). Minimum nodes (16.93) were reported in S_1 (60 cm x 30 cm). Closer spacing might increased competition among adjoining plants for available nutrients, water as well as for aerial space for accelerating growth. This prevents profuse branching and production of nodes on those branches for flowering and fruit set than the plants in other spacings. The results is also supported by Brar and Singh, (2016) and Jankar, (2020) in okra.

Internodal length (cm)**:** Data regarding effect of spacing on internodal length at 90 DAS was significant. The highest internodal length (8.62 cm) was measured in S_1 (60 cm x 30 cm) and the lowest internodal length (7.41 cm) was recorded in S_3 (120 cm x 30 cm). Plants in closer proximity compete more intensely for light. As a result, plants tend to elongate their internodal length. The plants in wider spacing had better access to resources and less competition allowing them to allocate more energy to other aspects of growth such as thicker stem, a greater number of branches, leaves etc., rather than elongating internodal length. The results are in concurrence with the findings reported by Ghadge, (2014) and Jankar, (2020) in okra.

The data regarding growth parameters studied after ratooning are presented in Table 2.

Plants sprouted after ratooning (%): In various spacing after ratooning maximum plants were sprouted in S_2 (90 cm x 30 cm) *i.e.* 79.69 % which was significantly superior over all other spacings. The minimum (67.70 %) plants were sprouted in S_3 (120 cm x 30 cm). Maximum plants (80.07 %) were sprouted in R_1 (Ratooning at 90 DAS). The minimum plants (67.36 %) were sprouted in R_2 (Ratooning at 105 DAS). In treatment R_3 (Control) ratooning was not carried out. In interaction, maximum plants (86.88 %) were sprouted in S_2R_1 (Spacing 90 cm x 30 cm with ratooning at 90 DAS) which was significantly superior over all other treatments. Minimum plants (62.08 %) were sprouted in S_3R_2 (Spacing 120 cm x 30 cm with ratooning at 105 DAS). The per cent plants sprouted in treatment combinations of S_1R_3 (Spacing 60 cm x 30 cm with no ratooning), S_2R_3 (Spacing 90 cm x 30 cm with no ratooning) and S_3R_3 (Spacing 120 cm x 30 cm with no ratooning) was zero as ratooning was not exposed. Due to increased availability of resources in wider spacing, plants might grown more robust, which led to development of larger stem girth and it might have greater food storage capacity. At 90 DAS, plants are still relatively young and might have sufficient reserves to support new growth. Thus, the sprouting percentage of plants in early ratooning with wider spacing was greater than late ratooned plants in closer spacing.

Plants survived after ratooning (%): Effect of ratooning on per cent plants survived was significant. Maximum plants were survived in S_2 (Spacing 90 cm x 30 cm) *i.e*. 74.38 % which was statistically superior over all other spacings. The minimum plants (60.00%) were survived in S_3 (120 cm x 30 cm). Maximum plants (76.04 %) were survived in R_1 (Ratooning at 90 DAS), whereas minimum plants (59.37 %) were survived in R_2 (Ratooned at 105 DAS). Ratooning was not carried out in treatment R_3. Maximum plants (81.88 %) were survived in S_2R_1 (Spacing 90 cm x 30 cm with ratooning at 90 DAS) which was crucially excellent over all other treatment combinations, whereas minimum plants (52.50 %) were sprouted in S_3R_2 (Spacing 120 cm x 30 cm with ratooning at 105 DAS). The plants survived in treatment combinations of S_1R_3 (Spacing 60 cm x 30 cm with no ratooning), S_2R_3 (Spacing 90 cm x 30 cm with no ratooning) and S_3R_3 (Spacing 120 cm x 30 cm with no ratooning) was zero as ratooning was not exposed.

Number of side branches: At 30 DAR, maximum number of branches (2.57) were observed in S_3 (120 cm x 30 cm). Minimum number of branches (2.15) were noted in S_1 (60 cm x 30 cm). Maximum number of branches (2.96) were found in R_1 (Ratooning at 90 DAS) which was followed by R_2 *i.e*. Ratooning at 105 DAS (2.17). The minimum number of branches (2.02) were seen in R_3 (No ratooning). The results recorded in present study are in close confirmity with the findings reported by Olasantan and Salau, (2008) and Singh, (2012) in okra and Page (2001), in brinjal. Ratooning at earlier stage resulted in a relatively higher number of new branches sprouted. Since, the plants are young and vigorous, with better potential of development of new branches. In wider spacing plant faces less competition for resources such as water, nutrients and light. As a result, they might have utilized more energy into developing thicker stems and accumulating reserves in their tissues. Therefore, the maximum number of branches were observed in early ratooning with wider spacing as compared to late ratooned plants in closer spacing.

Height after ratooning (cm): At 30 DAR, data regarding height of side branches sprouted after ratooning was non-significant and it ranged from 61.97 cm (S_2-90 cm x 30 cm) to 62.55 cm (S_1-60 cm x 30 cm). Highest height (166.53 cm) was recorded in R_3 (No ratooning). Among ratooning treatments, maximum height (10.63 cm) was recorded in R_1 (Ratooning at 90 DAS) and was at par (9.37 cm) with R_2 (Ratooning at 105 DAS). Singh, (2012) stated that apical dominance resides in terminal buds and gives direction to plant growth upward and inhibits the further development of lateral buds. But, after ratooning, the apical dominance is released which decreases the amount of auxins and increases cytokinin and promote cell division and branching, in this way, ratooning triggers the growth of new branches. At 90 DAS, the okra plant is generally in a more vigorous phase compared to 105 DAS. Hence, Ratooning during this earlier stage allows the plant to recover more effectively and produced longer new branches. In interaction, highest length of side branches (168.68 cm) was noted in S_1R_3 (Spacing 60 cm x 30 cm with no ratooning), while minimum height of side branches (9.10 cm) was reported in S_1R_2 (Spacing 60 cm x 30 cm with ratooning at 105 DAS).

Number of nodes on side branches: Maximum number of nodes (9.81) were observed in S_3 (120 cm x 30 cm) followed by S_2 (90 cm x 30 cm) which reported 9.41 nodes, whereas minimum number of nodes (9.07) were noted in S_1 (60 cm x 30 cm). Maximum number of nodes (23.33) were recorded in R_3 (No ratooning). Among ratooning treatments, more number of nodes on side branches (2.58) were observed in R_1 (Ratooning at 90 DAS). The results are analogous with the findings reported by Rajappa et al., (2020) and Singh, (2012) in okra. In interaction, maximum number of nodes on side branches (24.05) were noted in S_3R_3 (Spacing 120 cm x 30 cm with no ratooning), while minimum number of nodes on side branches (2.15) was reported in S_1R_2 (Spacing 60 cm x 30 cm with ratooning at 105 DAS). Younger plants have a more juvenility resulting in rapid regrowth and branching. As plants ages, their ability to produce new shoots and branches diminishes, while the plants in wider spacing have ample amount of energy reserves for the regrowth of plants after ratooning. Therefore, plants in wider spacing and ratooned at early stages had maximum number of nodes than plants ratooned late and plants in closer spacing.

Number of leaves on side branches: Maximum number of leaves (16.94) were observed in S_3 (120 cm x 30 cm). Minimum number of leaves (14.87) were noted in S_1 (60 cm x 30 cm). Maximum number of leaves (23.33) were recorded in R_3 (No ratooning). Among various ratooning treatments, more number of leaves on side branches (4.48) were recorded in R_1 (Ratooning at 90 DAS) and was at par (4.12) with R_2 (Ratooning at 105 DAS). In interaction, maximum number of leaves on side branches (41.75) were observed in S_3R_3 (Spacing 120 cm x 30 cm with no ratooning), while minimum number of leaves on side branches (3.85) were observed in S_1R_2 (Spacing 60 cm x 30 cm with ratooning at 105 DAS). Initiation of ratooning at an earlier growth stage, such as 90 DAS in wider spacing, generally resulted in a greater number of leaves due to availability of optimal conditions for regrowth and resource than plants ratooned late and plants in closer spacing.

The data pertaining to effect spacing and ratooning on various yield parameters are presented in Table 3.

Number of days required for first flowering before ratooning: Minimum days required for the appearance of the first flower (52.50 days) were noted in S_1 (60 cm x 30 cm), whereas maximum number of days (55.25) required for first flowering were observed in S_3 (120 cm x 30 cm). Plants in wider spacing had less competition to grow which led to larger plants with more leaves and branches before flowering. The larger plants required more number of days for transitioning into reproductive phase and might delay onset of first flowering. However in closer spacing, plants experienced stress due to population which might lead to early flowering. The results are in line with the findings reported by Ghadge, (2014) and Jankar, (2020) in okra. The effect of ratooning as well as interaction effect of spacing and ratooning on number of days required for the first flower was non-significant because ratooning treatment was not given till 90 days of sowing.

Number of days required for first flowering after ratooning: Effect of spacing on number of days required for first flowering after ratooning in okra was significant. Minimum days (36.17) required for first flowering was observed in S_3 (120 cm x 30 cm), whereas maximum number of days (38.66) required for the first flowering was observed in S_1 (60 cm x 30 cm). Maximum number of days (54.33) were required for plants in R_3 (No ratooning). But, in case of ratooning treatment, plants in R_1 (Ratooning at 90 DAS) taken minimum number of days (28.17) than R_2 *i.e.* Ratooning at 105 DAS (29.00). In interaction, minimum number of days (26.25) were observed in S_3R_1 (Spacing 120 cm x 30 cm with ratooning at 90 DAS). Maximum number of days (55.50) were required in S_3R_3 (Spacing 120 cm x 30 cm with no ratooning). Plants in wider spacing exhibited early flowering after ratooning might be due to less competition for resources such as light, water and nutrients. As a result, plants might have allocated more energy towards reproductive growth and flower production. However in ratooning, plants ratooned early might have more potential to grow quickly and produced flowers early after ratooning due to juvenility. Therefore, plants in wider spacing with ratooned at 90 DAS recorded minimum days to flower after ratooning.

Table 1. Effect of spacing and ratooning on growth of okra at 90 DAS

Treatment	**Plant height (cm)**				**Number of leaves**				**Number of branches**			
	R_1	**R_2**	**R_3**	**Mean**	**R_1**	**R_2**	**R_3**	**Mean**	**R_1**	**R_2**	**R_3**	**Mean**
S_1	146.08	145.36	145.73	**S_1**	146.08	145.36	145.73	**S_1**	146.08	145.36	145.73	**S_1**
S_2	142.88	139.00	140.58	**S_2**	142.88	139.00	140.58	**S_2**	142.88	139.00	140.58	**S_2**
S_3	126.58	127.10	128.43	**S_3**	126.58	127.10	128.43	**S_3**	126.58	127.10	128.43	**S_3**
Mean	**80.07**	**67.36**	**0.00**	**Mean**	**80.07**	**67.36**	**0.00**	**Mean**	**80.07**	**67.36**	**0.00**	**Mean**
	Result		**C.D. at 5%**		**Result**		**C.D. at 5%**		**Result**		**C.D. at 5%**	
S	**SIG**		6.33		**SIG**		1.17		**SIG**		0.10	
R	**NS**		-		**NS**		-		**NS**		-	
S X R	**NS**		-		**NS**		-		**NS**		-	
Treatment	**Stem girth (cm)**				**Number of nodes**				**Internodal length (cm)**			
	R_1	**R_2**	**R_3**	**Mean**	**R_1**	**R_2**	**R_3**	**Mean**	**R_1**	**R_2**	**R_3**	**Mean**
S_1	2.12	2.17	2.07	**S_1**	2.12	2.17	2.07	**S_1**	2.12	2.17	2.07	**S_1**
S_2	2.29	2.25	2.30	**S_2**	2.29	2.25	2.30	**S_2**	2.29	2.25	2.30	**S_2**
S_3	2.41	2.37	2.34	**S_3**	2.41	2.37	2.34	**S_3**	2.41	2.37	2.34	**S_3**
Mean	**2.28**	**2.26**	**2.24**	**Mean**	**2.28**	**2.26**	**2.24**	**Mean**	**2.28**	**2.26**	**2.24**	**Mean**
	Result		**C.D. at 5%**		**Result**		**C.D. at 5%**		**Result**		**C.D. at 5%**	
S	**SIG**		0.08		**SIG**		0.33		**SIG**		0.56	
R	**NS**		**-**		**NS**		-		**NS**		-	
S X R	**NS**		**-**		**NS**		-		**NS**		-	

(Note: DAS= Days after sowing)

Table 2. Effect of spacing and ratooning on growth of okra

Treatment	Plants sprouted after ratooning (%)				Plants survived after ratooning (%)				Number of side branches at 30 DAR			
	R_1	**R_2**	**R_3**	**Mean**	**R_1**	**R_2**	**R_3**	**Mean**	**R_1**	**R_2**	**R_3**	**Mean**
S_1	80.00	67.50	0.00	**S_1**	80.00	67.50	0.00	**S_1**	80.00	67.50	0.00	**S_1**
S_2	86.88	72.50	0.00	**S_2**	86.88	72.50	0.00	**S_2**	86.88	72.50	0.00	**S_2**
S_3	73.33	62.08	0.00	**S_3**	73.33	62.08	0.00	**S_3**	73.33	62.08	0.00	**S_3**
Mean	**80.07**	**67.36**	**0.00**	**Mean**	**80.07**	**67.36**	**0.00**	**Mean**	**80.07**	**67.36**	**0.00**	**Mean**
	Result		**C.D. at 5%**		**Result**		**C.D. at 5%**		**Result**		**C.D. at 5%**	
S	**SIG**		2.19		**SIG**		2.84		**SIG**		0.26	
R	**SIG**		1.79		**SIG**		2.32		**SIG**		0.26	
S X R	**SIG**		3.10		**SIG**		4.01		**SIG**		0.44	

Treatment	Height after ratooning (cm)				Number of nodes at 30 DAR				Number of leaves at 30 DAR			
	R_1	**R_2**	**R_3**	**Mean**	**R_1**	**R_2**	**R_3**	**Mean**	**R_1**	**R_2**	**R_3**	**Mean**
S_1	9.88	9.10	168.68	**S_1**	9.88	9.10	168.68	**S_1**	9.88	9.10	168.68	**S_1**
S_2	10.10	9.30	166.50	**S_2**	10.10	9.30	166.50	**S_2**	10.10	9.30	166.50	**S_2**
S_3	11.93	9.71	165.53	**S_3**	11.93	9.71	165.53	**S_3**	11.93	9.71	165.53	**S_3**
Mean	**10.63**	**9.37**	**166.90**	**Mean**	**10.63**	**9.37**	**166.90**	**Mean**	**10.63**	**9.37**	**166.90**	**Mean**
	Result		**C.D. at 5%**		**Result**		**C.D. at 5%**		**Result**		**C.D. at 5%**	
S	**NS**		-		**SIG**		0.35		**SIG**		0.65	
R	**SIG**		2.64		**SIG**		0.35		**SIG**		0.65	
S X R	**SIG**		4.65		**SIG**		0.62		**SIG**		1.12	

(Note: DAR= Days after ratooning)

Table 3. Effect of spacing and ratooning on yield of okra

Treatment	Number of days required for 1st flowering before ratooning				Number of days required for 1st flowering after ratooning				Number of harvests			
	R_1	R_2	R_3	Mean	R_1	R_2	R_3	Mean	R_1	R_2	R_3	Mean
S_1	52.25	52.00	53.25	**52.50**	31.00	31.75	53.25	**38.66**	21.90	21.73	24.58	**22.74**
S_2	52.25	52.00	54.25	**52.83**	27.25	28.50	54.25	**36.67**	23.00	22.71	25.35	**23.69**
S_3	56.00	54.25	55.50	**55.25**	26.25	26.75	55.50	**36.17**	23.90	23.15	26.05	**24.37**
Mean	**53.50**	**52.75**	**54.33**	**53.53**	**28.17**	**29.00**	**54.33**	**37.17**	**22.93**	**22.53**	**25.33**	**23.60**
	Result		**C.D. at 5%**		**Result**		**C.D. at 5%**		**Result**		**C.D. at 5%**	
S	**SIG**		1.70		**SIG**		1.77		**SIG**		0.58	
R	**NS**		-		**SIG**		1.77		**SIG**		0.58	
S X R	**NS**		-		**SIG**		3.07		**SIG**		1.00	
Treatment	**Number of fruits per plant**				**Yield per plant (g)**				**Yield (t/ha)**			
	R_1	R_2	R_3	Mean	R_1	R_2	R_3	Mean	R_1	R_2	R_3	Mean
S_1	19.35	18.08	20.23	**19.22**	261.03	255.24	297.59	**271.29**	14.50	14.18	16.52	**15.07**
S_2	20.38	19.65	20.73	**20.25**	278.34	275.26	317.31	**290.30**	10.31	10.19	11.79	**10.76**
S_3	21.00	20.63	21.28	**20.97**	293.25	286.66	333.04	**304.31**	8.15	7.96	9.21	**8.44**
Mean	**20.24**	**19.45**	**20.74**	**20.14**	**277.54**	**272.39**	**315.98**	**288.63**	**10.99**	**10.78**	**12.51**	**11.42**
	Result		**C.D. at 5%**		**Result**		**C.D. at 5%**		**Result**		**C.D. at 5%**	
S	**SIG**		0.47		**SIG**		10.37		**SIG**		0.40	
R	**SIG**		0.47		**SIG**		10.37		**SIG**		0.40	
S X R	**SIG**		0.82		**SIG**		17.97		**SIG**		0.70	

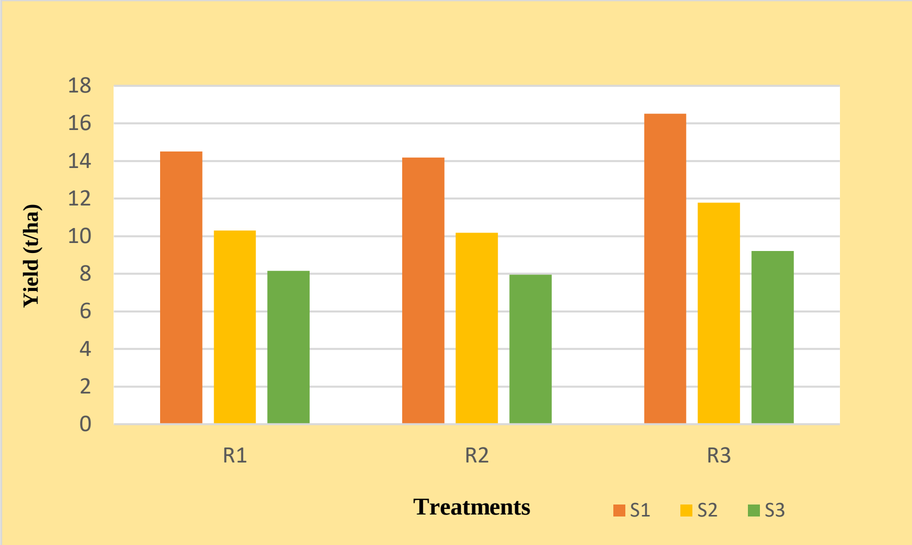

Fig. 1. Effect of spacing and ratooning on yield (t/ha) in okra

Number of fruits per plant: Maximum number of fruits (24.37) were reported in S_3 (120 cm x 30 cm), while minimum number of fruits (22.74) were recorded in S_1 (60 cm x 30 cm). Paththinge et al., (2008) stated that the lateral growth of the plant has been favored and tends to produce many lateral branches at wider spacing. As a result, number of fruits per plant increased. The results are in accordance with the findings reported by Firoz et al., (2007), Philip et al., (2010), Agba, (2011), Norman et al., (2019) in okra. Maximum number of fruits (25.33) were recorded in R_3 (No ratooning). Least number of fruits were observed in R_2-Ratooning at 105 DAS (22.53). Interaction effect of spacing and ratooning on total number of fruits per plant was significant. Maximum number of fruits (26.05) were obtained from S_3R_3 (Spacing 120 cm x 30 cm with no ratooning). Minimum number of fruits (21.73) were obtained from S_1R_2 (Spacing 60 cm x 30 cm with ratooning at 105 DAS). Plants in optimum spacing had more space to expand and developed root and shoot system due to less competition for the resources which might led to better nutrient uptake to become healthier plants. Ratooning of these healthy plants during early growth stage of okra helped plant to regrow faster and increase number of fruit production than ratooning at further stage of plants *i.e.* ratooning at 90 DAS.

Number of harvests: Maximum number of harvests (20.97) were reported in S_3 (120 cm x 30 cm), whereas minimum number of harvests (19.22) were recorded in S_1 (60 cm x 30 cm). Maximum number of harvests (20.74) were recorded in R_3 (No ratooning). Least number of harvests were observed in R_2 *i.e.* Ratooning at 105 DAS (19.45). Interaction effect of spacing and ratooning on total number of harvests per plant was significant. Maximum number of harvests (21.28) were reported in S_3R_3 (Spacing 120 cm x 30 cm with no ratooning). Minimum number of harvests (18.08) were recorded in S_1R_2 (Spacing 60 cm x 30 cm with ratooning at 105 DAS). Wider spacing (120 cm x 30 cm) and early ratooning (90 DAS) together created favorable conditions for extended harvestings. Plants in this combination were healthy and productive throughout the growing season which might lead in increased number of harvests.

Average yield per plant (g): Maximum yield (304.31 g) was reported in S_3 (120 cm x 30 cm) which was statistically superior over all other spacings, while minimum yield per plant (271.29 g) was recorded in S_1 (60 cm x 30 cm). These findings are analogous with results recorded by Amjad et al., (2002), Firoz et al., (2007) and Agba et al., (2011) in okra. Maximum yield (315.98 g) was recorded in R_3 (No ratooning). Minimum yield was observed in R_2 *i.e.* Ratooning at 105 DAS (272.39 g). results are in line with Nkansah et al., (2021) in tomato. In interaction, maximum yield per plant (333.04 g) was observed in S_3R_3 (Spacing 120 cm x 30 cm with no ratooning). Minimum yield (255.24 g) was recorded in S_1R_2 (Spacing 60 cm x 30 cm with ratooning at 105 DAS). Early ratooning aligned with optimal spacing might allowed plants to take full advantage of available resources with providing sufficient time for plants to fully recover and produced higher yield per plant during their life cycle. Hence, yield per plant in treatment of plants without ratooning and in spacing 120 x 30 was highest than other treatments.

Total yield: Maximum yield (15.07 t/ha) was reported in S_1 (60 cm x 30 cm). However, minimum total yield (8.44 t/ha) was recorded in S_3 (120 cm x 30 cm). The results are in accordance with Gupta et al., (1981), Maurya et al., (2013), Jha et al., (2018) and Jankar, (2020) in okra. Maximum yield (12.51 t/ha) was recorded in R_3 (No ratooning). Minimum yield was observed in R_2 (Ratooning at 105 DAS) (10.78 t/ha). The results were analogous to findings of Chauhan et al., (1996) in pigeon pea, Hoque et al., (2003) in cabbage, Sharma et al., (1978) and Page, (2001) in brinjal. In interaction, maximum yield (16.52 t/ha) was reported in S_1R_3 (Spacing 60 cm x 30 cm with no ratooning). Minimum yield (7.96 t/ha) was observed in S_3R_2 (Spacing 120 cm x 30 cm with ratooning at 105 DAS). This highest yield per hectare in the closer plant spacing was might be due to accommodation of double plant population as compared to wider plant spacing.

4. CONCLUSION

The present study revealed that spacing and ratooning influenced the growth and yield parameters of okra. Thus, considering the yield of okra, spacing of 60 cm x 30 cm without ratooning found to be beneficial for Konkan agro-climatic conditions. Yield per plant was low but total accumulation of yield per hectare was high. The yield from ratooning at 90 DAS was greater than ratooning at 105 DAS. The total yield obtained from without ratooned plants in closest spacing was highest than all treatments.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

I hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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