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Effect of different sowing time and planting distance on pod yield and quality of okra

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Abstract
The experiment titled "Effect of different sowing time and planting distance on yield and quality of okra (*Abelmoschus esculentus* (L.) Moench)" was carried out during the summer season of the year 2022 at the farm of Polytechnic in Horticulture, Junagadh Agricultural University, Junagadh. The study involved nine treatment combinations, including three sowing times: 2nd fortnight of February (S_1), 2nd fortnight of March (S_2), and 2nd fortnight of April (S_3), and three planting distances: 45 cm × 30 cm (D_1), 60 cm × 30 cm (D_2), and 75 cm × 30 cm (D_3). The experimental design used was a Randomized Block Design with a factorial concept, and the experiment was replicated three times. The results indicated that okra seeds sown during the 2nd fortnight of March (S_2) demonstrated superior performance in various aspects. This sowing time resulted in maximum pod length (12.91 cm), pod diameter (2.10 cm), number of pods per plant (15.22), average weight of 10 pods (120.52 g), total number of pickings (13.78), marketable pod yield per net plot (1.92 kg), marketable pod yield per hectare (4.62 t), chlorophyll content (28.44 SPAD), and ascorbic acid content (6.57 mg/100 g). In summary, sowing okra seeds during the 2nd fortnight of March led to improved yield and quality attributes, making it a favourable time for maximizing the production and nutritional content of okra.

Keywords: Okra, planting distance, sowing time, quality

1. Introduction
Okra, scientifically known as *Abelmoschus esculentus* (L.) Moench belongs to the Malvaceae family and is commonly referred to as Lady's Finger or Bhendi. It is a plant with a chromosome no. of 2n=130, as described by Gadwal *et al.* in 1968 [3]. Believed to have originated in tropical or subtropical regions of Africa, okra is now widely cultivated as a significant warm-season vegetable crop in various parts of the world, including tropical and subtropical areas and the Mediterranean region. While primarily grown as a rain-fed crop, okra thrives when provided with adequate irrigation during the *Kharif* and summer seasons. It holds a prominent place in Indian cuisine as one of the most popular and cherished vegetables. Beyond its culinary uses, okra has substantial industrial and medicinal importance. The plant is primarily cultivated for its tender and edible fruits, which are used in various culinary preparations.

Additionally, okra fruits can be processed and preserved in forms like canned, fried, dehydrated, or frozen to be enjoyed even outside their regular season. They can also be boiled and served as a salad or used as a flavorful addition to soups. Interestingly, the roots and stems of the okra plant play a role in the sugar and jaggery-making process by cleaning the cane juice, as noted by Chauhan in 1972. In Turkey, the mature seeds of okra are roasted, crushed, and utilized as a substitute for coffee (Mehta, 1959) [8]. Moreover, the mature fruits and their stems contain crude fibre, which finds application in the paper industry. Extracts from okra seeds serve as an alternative source of edible oil. The greenish-yellow edible oil derived from okra seeds is rich in unsaturated fats, such as oleic acid and linoleic acid, which contribute to its pleasant flavour and aroma. The seed itself contains a substantial 40% oil content, making it a valuable source of oil.

In addition, okra has been found to be effective against conditions like spermatorrhea, chronic dysentery and genitourinary diseases, as noted by Nandkarni in 1927. Okra's yield and quality are significantly impacted by the sowing of dates. Because good cultivars seeded at the wrong time provide low yields, various cultivars require varied sowing times. Sowing at the right time is essential to increasing okra production. Plants that are sown at the right time benefit from climatic conditions, have long growth periods, receive adequate rainfall and experience ideal temperatures during establishment and the early vegetative stage.

Fresh fruit yield and financial gains are consequently possible. Incorrect planting dates result in shorter duration, insufficient use of rainfall, low temperatures during establishment and the early vegetative stage and fruit that takes longer to reach marketable size. Okra's fruit yield is reduced as a result of the delayed seeding. A higher fresh weight of fruit, more fruits per plant, and a higher fruit output per plant are all benefits of seeding at the right time.

Planting density plays a crucial role in the cultivation of okra. The right plant density is vital to ensure optimal growth, yield, and fruit quality. Inadequate plant spacing can lead to poor growth, low yield, and inferior fruit quality. On the other hand, excessive plant density can result in vigorous growth but may lead to reduced fruit quality and overall output due to increased competition among plants. Farmers often encounter challenges related to plant spacing, making it a critical aspect of crop production. Proper spacing is essential as it reduces competition between plants and weeds, allowing okra plants to thrive. Optimum spacing promotes favourable growth conditions, higher yield and improved fruit quality in okra production. Achieving the right plant density is of utmost importance because it directly influences plant development and ultimately impacts the overall yield of okra. Therefore, careful consideration and implementation of appropriate plant spacing are vital for successful okra cultivation, ensuring better crop productivity and quality.

2. Materials and Methods

The experiment was carried out during the summer season of 2022 at the Polytechnic in Horticulture, Junagadh Agricultural University, Junagadh. It followed a Randomized Block Design with a factorial concept and was replicated thrice. The study included three sowing time treatments, namely S_1 (2^{nd} fortnight of February), S_2 (2^{nd} fortnight of March) and S_3 (2^{nd} fortnight of April) as factor-S, and three planting distance treatments, D_1 (45 cm × 30 cm), D_2 (60 cm × 30 cm), and D_3 (75 cm × 30 cm) as factor-B. Each treatment combination was replicated three times. To prepare the experimental field, thorough ploughing was done, and the soil was brought to a fine tilth. Harrowing and planking were carried out before laying out the plots. The required area was marked, and a total of 27 plots were set up according to the designated layout plan. At each spot, two to three okra seeds were sown, and after germination, thinning of seedlings was performed to maintain one plant per stand. For soil fertility, fertilizers were applied at the rate of 150 kg/ha nitrogen and 50 kg/ha phosphorus. During the cropping period, irrigation was carried out based on the crop's specific water needs.

In summary, the experiment was conducted using a Randomized Block Design with factorial treatment combinations and replicated thrice. The field preparation included ploughing, harrowing, and planking and specific planting distances and sowing times were applied for the okra crop. Adequate fertilizers and irrigation were provided to support the growth and development of the plants.

3. Result and Discussion

The effect of different sowing times and planting distances with their interaction effect on yield and quality parameters are tabulated in Tables 1, 2 and 3.

4. Yield Parameters

4.1 Sowing time

The investigation results clearly showed that different sowing times had a significant impact on various yield parameters of okra. Specifically, sowing okra seeds during the 2^{nd} fortnight of March resulted in a significant increase in pod length (12.91 cm), pod diameter (2.10 cm), number of pods per plant (15.22), average weight of 10 pods (120.52 g), total number of pickings (13.78), marketable pod yield per net plot (1.92 kg), and marketable pod yield per hectare (4.62 t). These findings are consistent with previous research by Undie and Litio (2018) [12], Bake *et al.* (2017) [1], Morwal and Patel (2017) [10], Ghannad *et al.* (2014) [4], and Ijoyah *et al.* (2010) [5] in the context of okra. Additionally, similar results were reported by Vasava *et al.* (2023) [13] in their study on Brinjal.

In summary, the study clearly indicates that sowing okra seeds during the 2nd fortnight of March is advantageous for obtaining higher yields and improved quality, aligning with the findings from previous research in both okra and brinjal crops.

4.2 Planting distance

The collected data clearly indicated that different planting distances significantly influenced various yield parameters of okra. Treatment D_3 (45 cm × 30 cm) demonstrated the maximum pod length (11.94 cm), pod diameter (1.96 cm), and an average weight of 10 pods (112.54 g). Meanwhile, treatment D_2 (60 cm × 30 cm) showed the highest number of pods per plant (13.86), and treatments D_1 (45 cm × 30 cm) and D_2 (60 cm × 30 cm) resulted in the maximum total number of pickings (12.44).

Moreover, treatment D_1 (45 cm × 30 cm) exhibited the highest marketable pod yield per net plot (1.88 kg) and marketable pod yield per hectare (4.36 t). These findings are consistent with previous studies conducted by Bake *et al.* (2017) [1], Morwal and Patel (2017) [10], Maurya *et al.* (2013) [7], and Moniruzzaman *et al.* (2007) [9] in the context of okra.

In summary, the results clearly indicate that different planting distances have a significant impact on various yield parameters of okra, with treatment D_3 (45 cm × 30 cm) providing the best results in terms of pod length, pod diameter, and average weight of 10 pods. Treatment D_2 (60 cm × 30 cm) resulted in the highest number of pods per plant, while treatments D_1 (45 cm × 30 cm) and D_2 (60 cm × 30 cm) produced the maximum total number of pickings. Additionally, treatment D_1 (45 cm × 30 cm) yielded the highest marketable pod yield per net plot and per hectare, aligning with findings from previous research in the field of okra cultivation.

4.3 Interaction effect

The yield parameters of okra were significantly influenced by the interaction effect of sowing time and planting distance. Treatment combination S_2D_3 (2^{nd} fortnight of March + 75 cm × 30 cm) resulted in the maximum number of pods per plant (16.73). Similarly, treatment combination S_2D_2 (2^{nd} fortnight of March + 60 cm × 30 cm) reported the highest marketable pod yield per net plot (2.46 kg), while treatment combination S_1D_1 (2^{nd} fortnight of February + 45 cm × 30 cm) and treatment combination S_2D_2 (2^{nd} fortnight of March + 60 cm × 30 cm) yielded the highest marketable pod yield per hectare (5.61 t). These findings are consistent with previous research conducted by Undie and Litio (2018) [12], Bake *et al.* (2017) [1], Morwal and Patel (2017) [10], Ghannad *et al.* (2014) [4], and Ijoyah *et al.* (2010) [5] in the context of okra.

In conclusion, the study highlights the significant influence of the interaction between sowing time and planting distance on the yield parameters of okra. Treatment combinations involving specific sowing times and planting distances resulted in higher pod numbers and greater marketable pod yields, aligning with the findings from previous research in the field of okra cultivation.

5. Quality parameters

5.1 Sowing time

The quality parameters of okra were significantly impacted by the different sowing times. Specifically, sowing okra seeds during the 2nd fortnight of March resulted in significantly higher chlorophyll content (28.44 SPAD) and maximum ascorbic acid content (6.57 mg/100 g). However, the crude fibre content showed no significant variation with different sowing times. These findings are consistent with the results of a study conducted by Kumar *et al.* (2015) [6] in onion, further confirming the influence of sowing time on the quality attributes of crops.

In summary, the study demonstrated that the timing of sowing has a significant effect on the chlorophyll and ascorbic acid content of okra. Sowing during the 2nd fortnight of March yielded higher levels of these quality parameters, while crude fibre content remained relatively consistent across different sowing times. These results align with similar observations made in onion cultivation by Kumar *et al.* (2015) [6].

5.2 Planting distance

The quality parameters of okra were notably affected by different planting distances. Treatment with a plant spacing of 60 cm × 30 cm resulted in the highest chlorophyll content (26.99 SPAD), while treatment D_3 (75 cm × 30 cm) exhibited the maximum ascorbic acid content (6.53 mg/100 g). However, the various planting distances had no significant impact on the crude fibre content of okra pods. These findings align closely with the results reported by Kumar *et al.* (2015) [6], providing further evidence of the influence of planting distance on the quality attributes of crops.

In conclusion, the study revealed that different planting distances significantly affected the chlorophyll and ascorbic acid content of okra. Treatment with a spacing of 60 cm × 30 cm showed higher chlorophyll content, while treatment D_3 (75 cm × 30 cm) demonstrated greater ascorbic acid content. However, the crude fibre content remained unaffected by the varied planting distances. These observations are in agreement with the findings of Kumar *et al.* (2015) [6] in a similar context.

5.3 Interaction effect

The interaction effect of different sowing times and planting distances did not show any significant influence on all three quality parameters.

Table 1: Effect of different sowing time and planting distance on yield parameters of okra (*Abelmoschus esculentus* (L.) Moench)

Treatment	Pod length (cm)	Pod diameter (cm)	Average weight of 10 pods (g)	Total number of pickings
Factor A: Sowing time (S) (Three levels)				
S_1: 2nd fortnight of February	11.05	1.86	107.94	12.56
S_2: 2nd fortnight of March	12.91	2.10	120.52	13.78
S_3: 2nd fortnight of April	10.15	1.63	93.76	10.11
S.Em ±	0.152	0.062	1.838	0.225
C. D. at 5%	0.43	0.18	5.23	0.64
Factor B: Planting distance (D) (Three levels)				
D_1: 45 cm × 30 cm	10.79	1.73	101.51	12.44
D_2: 60 cm × 30 cm	11.37	1.89	108.17	12.44
D_3: 75 cm × 30 cm	11.94	1.96	112.54	11.56
S.Em ±	0.152	0.062	1.838	0.225
C. D. at 5%	0.43	0.18	5.23	0.64
Interaction (S X D)				
S.Em ±	0.263	0.107	3.184	0.389
C. D. at 5%	NS	NS	NS	NS
C. V. %	8.01	9.91	7.13	6.54

Table 2: Effect of different sowing time and planting distance on yield parameters of okra (*Abelmoschus esculentus* (L.) Moench)

Treatment	Number of pods per plant	Marketable pod yield (kg/net plot)	Marketable pod yield (t/ha)
Factor A: Sowing time (S) (Three levels)			
S_1: 2nd fortnight of February	14.52	1.78	4.26
S_2: 2nd fortnight of March	15.22	1.92	4.62
S_3: 2nd fortnight of April	9.90	0.95	2.33
S. Em ±	0.205	0.039	0.099
C. D. at 5%	0.58	0.11	0.28
Factor B: Planting distance (D) (Three levels)			
D_1: 45 cm × 30 cm	12.10	1.88	4.36
D_2: 60 cm × 30 cm	13.86	1.82	4.20
D_3: 75 cm × 30 cm	13.69	0.95	2.64
S. Em ±	0.205	0.039	0.099
C. D. at 5%	0.58	0.11	0.28
Interaction (S X D)			
S_1D_1	13.07	2.42	5.61
S_1D_2	16.03	2.02	4.68
S_1D_3	14.47	0.89	2.48
S_2D_1	14.10	2.16	4.99

S_2D_2	14.83	2.46	5.61
S_2D_3	16.73	1.17	3.25
S_3D_1	9.13	1.07	2.49
S_3D_2	10.70	1.00	2.31
S_3D_3	9.87	0.78	2.18
S.Em ±	0.355	0.067	0.172
C.D. at 5%	1.01	0.19	0.49
C.V. %	8.66	7.48	7.48

Table 3: Effect of different sowing time and planting distance on quality parameters of okra (*Abelmoschus esculentus* (L.) Moench)

Treatment	Chlorophyll content (SPAD)	Ascorbic acid content (mg/100 g)
Factor A: Sowing time (S), (Three levels)		
S_1: 2nd fortnight of February	25.98	6.47
S_2: 2nd fortnight of March	28.44	6.57
S_3: 2nd fortnight of April	24.47	6.26
S.Em ±	0.202	0.044
C.D. at 5%	0.57	0.13
Factor B: Planting distance (D), (Three levels)		
D_1: 45 cm × 30 cm	25.67	6.36
D_2: 60 cm × 30 cm	26.99	6.40
D_3: 75 cm × 30 cm	26.23	6.53
S.Em ±	0.202	0.044
C.D. at 5%	0.57	0.13
Interaction (S X D)		
S.Em ±	0.349	0.077
C.D. at 5%	NS	NS
C.V. %	4.30	5.08

6. Conclusion

Based on the findings of the present investigation, it can be concluded that sowing okra seeds during the 2nd fortnight of March (S_2) resulted in better performance in both yield and quality parameters. On the other hand, planting okra at a wider spacing of 75 cm × 30 cm (D_3) showed better outcomes for yield and quality parameters. However, it is noteworthy that the highest marketable pod yield was obtained from plants grown at a closer spacing of 60 cm × 30 cm (D_2). In light of these results, for achieving maximum yield and maintaining quality, it is recommended to sow okra during the 2nd fortnight of March and utilize a spacing of 60 cm × 30 cm. This combination has demonstrated superior performance in terms of both yield and quality parameters, making it an optimal choice for okra cultivation.

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