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Effect of different sowing time and planting distance on Okra growth

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Abstract
The experiment titled "Effect of different sowing times and planting distances on the growth and yield of okra (*Abelmoschus esculentus* (L.) Moench)" was carried out during the summer season of 2022 at the Polytechnic in Horticulture, Junagadh Agricultural University, Junagadh. The study used a Randomized Block Design with the factorial concept, consisting of nine treatment combinations. These combinations included three sowing times: 2^{nd} fortnight of February (S_1), 2^{nd} fortnight of March (S2), and 2^{nd} fortnight of April (S_3), along with three planting distances: 45 cm × 30 cm (D_1), 60 cm × 30 cm (D2), and 75 cm × 30 cm (D_3). Each treatment combination was replicated three times. The results of the experiment demonstrated that okra seeds sown during the 2^{nd} fortnight of March (S2) exhibited the most favorable outcomes in various growth and yield parameters. These included the tallest plant height (98.64 cm), the highest number of primary branches (2.18), the largest number of flowering nodes (16.87), the longest days to the last picking (90.11), the longest pod length (12.91 cm), widest pod diameter (2.10 cm), the greatest number of pods per plant (15.22), the heaviest average weight of 10 pods (120.52 g), highest total number of pickings (13.78), as well as the most substantial marketable pod yield of 1.92 kg per net plot and 4.62 t per hectare. However, when okra seeds were sown during the 2^{nd} fortnight of April, it resulted in the shortest time to 50% flowering (42.89) and the earliest first picking (46.78). Regarding the planting distance, the configuration of 75 cm × 30 cm exhibited the tallest plant height (82.20 cm), longest pod length (11.94 cm), widest pod diameter (1.96 cm), highest number of pods per plant (13.86), and heaviest average weight of 10 pods (112.54 g). Nonetheless, the treatment with a planting distance of 45 cm × 30 cm (D_1) produced the greatest marketable pod yield, with 1.88 kg per net plot and 4.36 t per hectare.
In terms of interactions between sowing time and planting distance, the combination of sowing during the 2^{nd} fortnight of April and planting at 60 cm × 30 cm showed the shortest time to 50% flowering (41.67) and the earliest first picking (45.33). On the other hand, among the interactions involving sowing during the 2^{nd} fortnight of March and planting at 60 cm × 30 cm (S2D2), the final harvest resulted in the highest number of flowering nodes (18.97), the greatest number of pods per plant (14.83), and the most substantial marketable pod yield of 2.46 kg per net plot and 5.61 t per hectare.

Keywords: Okra, sowing time, planting distance, fortnight, marketable pod yield

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench), commonly known as Lady's Finger or Bhendi, belongs to the Malvaceae family and has a chromosome number of 2n=130 (Gadwal *et al.*, 1968) [5]. Its primary center of origin is believed to be tropical or subtropical Africa (Chauhan, 1972) [2]. This warm-season vegetable crop is widely cultivated in Mediterranean regions, as well as tropical and subtropical areas worldwide. While it is predominantly grown as a rainfed crop, it also thrives under irrigated conditions during the *Kharif* and summer seasons.

Okra holds significant importance in Indian cuisine and is a popular vegetable in the diet. Apart from its culinary value, it possesses medicinal and industrial uses. The vegetable is harvested for its tender fruits, which are commonly used in various dishes such as curries and soups. Additionally, okra can be processed in different forms like canning, frying, dehydration, and freezing for consumption during the off-season. It is also enjoyed boiled and served as a salad or as a complement to soups. Okra plants have versatile uses beyond their culinary value. The root and stem of okra are utilized in the manufacturing process of jaggery and sugar to clean cane juice (Chauhan, 1972) [2]. In Turkey, ripe okra seeds are roasted, ground, and served as a coffee substitute (Mehta, 1959) [11]. Moreover, the matured fruits and stems, rich in crude fiber, find application in the paper industry.

The seeds of okra serve as an alternative source of edible oil. Extracts from these seeds yield a greenish-yellow edible oil with a pleasant taste and aroma.

This oil is particularly high in unsaturated fats like oleic acid and linoleic acid, making it beneficial for health. The seed content boasts a substantial oil percentage of around 40%. Furthermore, okra has been known for its medicinal properties. It is considered helpful in addressing genitourinary disorders, spermatorrhea, and chronic dysentery (Nandkarni, 1927) [14].

The timing of sowing plays a crucial role in determining the seed production, growth, and overall yield of okra. Different cultivars have specific requirements for sowing times, and if good cultivars are sown at inappropriate times, it can result in poor yields. Therefore, selecting a proper and suitable sowing date is essential to maximize okra production.

When okra plants are sown at the right time, they benefit from favorable climatic conditions, longer growth duration, adequate rainfall, and optimal temperatures during establishment and early vegetative stages. Consequently, this leads to higher fresh fruit yield and better economic returns. On the other hand, improper sowing dates can lead to shorter growth durations, inadequate utilization of rainfall, exposure to cooler temperatures during establishment and early vegetative stages, and delayed time for fruits to reach marketable size. Delayed sowing, in particular, can cause a decrease in fruit yield for okra (Ghannad *et al*., 2014) [6].

Choosing the appropriate sowing time ensures a higher fresh weight of fruits, an increased number of fruits per plant, and ultimately boosts the fruit yield per plant. Therefore, careful consideration and adherence to the right sowing date are vital for maximizing okra productivity. Planting density is a crucial factor that significantly influences the growth and yield of okra. If the plant spacing is not optimized, it can result in poor growth, low yield, and inferior quality fruits. On the other hand, excessively high plant density can lead to vigorous growth, lower fruit quality, and reduced yield due to increased competition among plants (Moniruzzaman *et al*., 2007) [12].

Farmers often face challenges in determining the appropriate plant spacing for okra cultivation. Implementing the correct spacing is of utmost importance as it helps reduce competition between plants and weeds. When the right plant spacing is adopted in okra farming, it positively impacts growth, yield, and fruit quality. Achieving the optimum plant density is a critical factor in obtaining a high yield of okra, as it directly affects plant growth and productivity. The issue of improper plant spacing is a significant aspect of crop ecology, production, and management, which can limit crop yields. Incorrect spacing can lead to reduced plant density per hectare or overcrowding, making essential farm operations like weeding more challenging. Maintaining an increased plant population can boost yield per unit area up to a certain threshold. However, beyond this point, the yield may decline due to limitations in utilizing the natural resources necessary for optimal plant growth. Therefore, striking the right balance in plant spacing is essential to maximize okra production and overall farm efficiency.

Materials and Methods

The experiment was conducted in 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 three times. The treatments included three sowing times: S_1 (2nd fortnight of February), S2 (2nd fortnight of March), and S3 (2nd fortnight of April), and three planting distances: D_1 (45 cm × 30 cm), D2 (60 cm × 30 cm), and D_3 (75 cm × 30 cm).

Before commencing the experiment, the plot area was thoroughly plowed and prepared to achieve a fine tilth. Harrowing and planking were performed before laying out the experimental field. A total of 27 plots were created according to the layout plan. Each plot received two to three okra seeds, and thinning was carried out after germination to maintain one plant per stand. For fertilization, the soil was treated with 150 kg/ha of nitrogen and 50 kg/ha of phosphorus. Throughout the cropping period, the experimental plot was irrigated based on the specific needs of the plants.

Result and Discussion

Tables 1, 2, 3, and 4 present the impact of various sowing times and planting distances, along with their interaction effects, on different growth and yield attributes of the okra plants. These tables provide detailed information and results regarding the performance of the different treatment combinations in the experiment.

Growth parameters

Sowing time

The data analysis revealed that the sowing time significantly influenced several growth parameters of okra plants, including plant height, number of primary branches, days to 50% flowering, number of flowering nodes at the final harvest, days to the first picking, and days to the last picking.

Okra seeds sown during the 2nd fortnight of March exhibited the most remarkable results, with significantly higher plant height (98.64 cm), number of primary branches (2.18), and number of flowering nodes (16.87) compared to the other treatments. Additionally, this sowing time resulted in the maximum number of days to the last picking (90.11). Conversely, the treatment with seeds sown in the 2nd fortnight of April (S3) showed the shortest days to 50% flowering (42.89) and the earliest days to the first picking (46.78).

These findings align with previous studies conducted by Hussain *et al*. (2006) [7], Firoz *et al*. (2007) [4], Sood and Kaur (2019) [16], Dash *et al*. (2013) [3], Ijoyah *et al*. (2010) [8], Kumar *et al*. (2016) [9], and Morwal and Patel (2017) [13] on okra. Vasava *et al*. (2023) [18] also reported similar results in their research. In summary, sowing time has a significant impact on the growth parameters of okra, and the 2nd fortnight of March emerged as the most favorable time for achieving optimal plant height, branch development, flowering nodes, and days to the last picking. On the other hand, the 2nd fortnight of April led to the shortest days to 50% flowering and first picking.

Planting distance

Among the different planting distances, only plant height was significantly affected. The spacing of 75 cm × 30 cm resulted in significantly higher plant height (82.20 cm). This finding is consistent with previous studies conducted by Ram *et al*. (2013) [15], Morwal and Patel (2017) [13], and Bake *et al.* (2017) [1] in the context of okra.

However, when considering the interaction effect of sowing time and planting distance, all the growth parameters showed significant variations. The treatment combination of S_3D2 (2nd fortnight of April + 60 cm × 30 cm) exhibited the shortest time taken to reach 50% flowering (41.67) and the earliest days taken to the first picking (45.33). Similarly, the treatment combination of S2D2 (2nd fortnight of March + 60 cm × 30 cm) showed the maximum number of flowering nodes (18.97) at the final harvest. These results align with those reported by Hussain *et al.* (2006) [7] in their research on okra.

In conclusion, the planting distance had a significant impact only on plant height, with 75 cm × 30 cm spacing resulting in the tallest plants. However, when considering the combined effect of sowing time and planting distance, various growth parameters displayed significant differences. S_3D2 (2nd fortnight of April + 60 cm × 30 cm) was found to be the most favorable combination for achieving the shortest time to flowering and first picking, while S2D2 (2nd fortnight of March + 60 cm × 30 cm) led to the maximum number of flowering nodes at the final harvest.

Yield parameters

Sowing time

The investigation data clearly indicated that different sowing periods had a significant influence on various yield parameters of okra, including pod length, pod diameter, average weight of 10 pods, number of pods per plant, total number of pickings, marketable pod yield per net plot, and per hectare.

Okra seeds sown during the 2nd fortnight of March exhibited the most favorable results, with significantly longer pod length (12.91 cm), wider pod diameter (2.10 cm), a higher number of pods per plant (15.22), heavier average weight of 10 pods (120.52 g), greater total number of pickings (13.78), and higher marketable pod yield per net plot (1.92 kg) and per hectare (4.62 t). These findings are in close agreement with the results reported by Undie and Litio (2018) [17], Morwal and Patel (2017) [13], Bake *et al.* (2017) [1], Ghannad *et al.* (2014) [6], and Ijoyah *et al.* (2010) [8] in their respective studies on okra.

In summary, sowing okra seeds during the 2nd fortnight of March proved to be the most advantageous for achieving superior yield parameters, as demonstrated by the longer and wider pods, greater pod weight, increased number of pods per plant, and overall higher marketable pod yield per net plot and per hectare. These results are consistent with previous research conducted on okra by various researchers.

Planting distance

The data analysis revealed that different planting distances had a significant influence on several yield parameters of okra, including pod length, pod diameter, average weight of 10 pods, number of pods per plant, total number of pickings, marketable pod yield per net plot, and per hectare.

Among the different planting distances, treatment D_3 (45 cm × 30 cm) demonstrated the most favorable results, with significantly longer pod length (11.94 cm), wider pod diameter (1.96 cm), and a higher average weight of 10 pods (112.54 g). Treatment D2 (60 cm × 30 cm) resulted in the maximum number of pods per plant (13.86), and both treatments D_1 (45 cm × 30 cm) and D2 (60 cm × 30 cm) recorded the highest total number of pickings (12.44). Additionally, treatment D_1 (45 cm × 30 cm) achieved the highest marketable pod yield per net plot (1.88 kg) and per hectare (4.36 t). These findings are in close agreement with the results reported by Maurya *et al*. (2013) [10], Monniruzaman *et al.* (2007) [12], Morwal and Patel (2017) [13], and Bake *et al.* (2017) [1] in their respective studies on okra.

In conclusion, the different planting distances had a significant impact on the yield parameters of okra, with treatment D_3 (45 cm × 30 cm) showing the most favorable results in terms of pod length, pod diameter, and average weight of 10 pods. Treatment D2 (60 cm × 30 cm) resulted in a higher number of pods per plant, while both treatments D_1 (45 cm × 30 cm) and D2 (60 cm × 30 cm) recorded the highest total number of pickings. Finally, treatment D_1 (45 cm × 30 cm) demonstrated the highest marketable pod yield per net plot and per hectare. These findings align with previous research conducted on okra by various researchers

Interaction effect

The interaction effect of sowing time and planting distance had a significant influence on the yield parameters of okra. Treatment combination S2D_3 (2nd fortnight of March + 75 cm × 30 cm) resulted in the highest number of pods per plant (16.73). Additionally, treatment combination S2D2 (2nd fortnight of March + 60 cm × 30 cm) exhibited the highest marketable pod yield per net plot (2.46 kg), while treatment combination S_1D_1 (2nd fortnight of February + 45 cm × 30 cm) and S2D2 (2nd fortnight of March + 60 cm × 30 cm) recorded the highest marketable pod yield per hectare (5.61 t). These findings are in close agreement with the results reported by Undie and Litio (2018) [17], Morwal and Patel (2017) [13], Bake *et al.* (2017) [1], Ghannad *et al.* (2014) [6], and Ijoyah *et al.* (2010) [8] in their respective studies on okra.

In summary, the interaction between sowing time and planting distance had a significant impact on the yield parameters of okra. Treatment combinations such as S2D_3, S2D2, and S_1D_1 demonstrated the most favorable results in terms of the number of pods per plant and marketable pod yield per net plot and per hectare. These findings further validate the importance of considering both sowing time and planting distance to optimize the yield of okra, as supported by previous research conducted on the crop.

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

Treatment	Plant height (cm)	No. of primary branches per plant	Days to last picking
Factor A: Sowing time (S) (Three levels)			
S1: 2nd fortnight of February	77.57	1.62	87.44
S2: 2nd fortnight of March	98.64	2.18	90.11
S3: 2nd fortnight of April	58.63	1.44	79.89
S. Em ±	0.753	0.045	0.895
C. D. at 5%	2.14	0.13	2.45
Factor B: Planting distance (D) (Three levels)			
D1: 45 cm × 30 cm	75.56	1.73	86.67
D2: 60 cm × 30 cm	77.08	1.78	84.78
D3: 75 cm × 30 cm	82.20	1.73	86.00
S. Em ±	0.753	0.045	0.859
C. D. at 5%	2.14	NS	NS
Interaction (S X D)			
S. Em ±	1.304	0.078	1.489
C. D. at 5%	NS	NS	NS
C. V.%	6.01	7.76	6.00

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

Treatment	Days to 50% flowering	No. of flowering nodes at harvest	Days to first picking
Factor A: Sowing time (S) (Three levels)			
S1: 2nd fortnight of February	47.56	16.02	52.33
S2: 2nd fortnight of March	45.56	16.87	50.00
S3: 2nd fortnight of April	42.89	12.02	46.78
S. Em ±	0.676	0.365	0.739
C. D. at 5%	1.92	1.04	1.64
Factor B: Planting distance (D) (Three levels)			
D1: 45 cm × 30 cm	46.11	14.77	50.56
D2: 60 cm × 30 cm	44.78	15.59	49.22
D3: 75 cm × 30 cm	45.11	14.56	49.33
S. Em ±	0.676	0.365	0.739
C. D. at 5%	NS	NS	NS
Interaction (S X D)			
S1D1	51.67	17.13	56.33
S1D2	46.00	15.70	51.33
S1D3	45.00	15.23	49.33
S2D1	43.67	16.27	48.33
S2D2	46.67	18.97	51.00
S2D3	46.33	15.37	50.67
S3D1	43.00	10.90	47.00
S3D2	41.67	12.10	45.33
S3D3	44.00	13.07	48.00
S. Em ±	1.171	0.632	1.280
C. D. at 5%	3.33	1.80	3.64
C. V.%	8.47	7.31	6.46

Table 3: 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)				
S1: 2nd fortnight of February	11.05	1.86	107.94	12.56
S2: 2nd fortnight of March	12.91	2.10	120.52	13.78
S3: 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)				
D1: 45 cm × 30 cm	10.79	1.73	101.51	12.44
D2: 60 cm × 30 cm	11.37	1.89	108.17	12.44
D3: 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 3: 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)			
S1: 2nd fortnight of February	14.52	1.78	4.26
S2: 2nd fortnight of March	15.22	1.92	4.62
S3: 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)			
D1: 45 cm × 30 cm	12.10	1.88	4.36
D2: 60 cm × 30 cm	13.86	1.82	4.20
D3: 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)			
S1D1	13.07	2.42	5.61
S1D2	16.03	2.02	4.68
S1D3	14.47	0.89	2.48

S2D1	14.10	2.16	4.99
S2D2	14.83	2.46	5.61
S2D3	16.73	1.17	3.25
S3D1	9.13	1.07	2.49
S3D2	10.70	1.00	2.31
S3D3	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

Conclusion

Based on the findings from the current investigation, it can be concluded that okra seeds sown during the 2nd fortnight of March (S2) exhibited superior performance in terms of vegetative, flowering, and yield parameters. On the other hand, sowing seeds at wider spacing (D_3: 75 cm × 30 cm) resulted in better vegetative growth. However, when considering marketable pod yield, the plants with closer spacing (D2: 60 cm × 30 cm) outperformed others, producing the highest marketable pod yield. Regarding the interaction effect of sowing time and planting distance, the maximum marketable fruit yield was observed in plants sown during the 2nd fortnight of March at the spacing of 60 cm × 30 cm (S2D2). Therefore, for achieving the maximum yield of okra, it is recommended to sow the seeds during the 2nd fortnight of March at a spacing of 60 cm × 30 cm.

In summary, the best combination for optimizing okra yield involves sowing during the 2nd fortnight of March at a spacing of 60 cm × 30 cm. This will lead to improved vegetative growth, flowering, and overall marketable pod yield, providing valuable insights for okra cultivation practices

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