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Optimizing Yield and Quality of Garlic (*Allium sativum* L.) cv. Anand Kesari through Planting Time and Plant Spacing Management

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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 field experiment was conducted during rabi season of the year 2022-23 at B. A. College of Agriculture, Anand Agricultural University. There were nine treatments consisting of three planting time (P_1: 1st week of October, P_2: 3rd week of October and P_3: 1st week of November) and spacing (S_1: 15 x 10 cm, S_2: 15 x 15 cm and S_3: 20 x 10 cm). Results revealed that planting time P2 (3rd week of October) led to the most favorable outcomes, with bulb diameter (4.46 cm), bulb weight

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(13.18), yield (1.93 kg/plot and 60.70 q/ha). Spacing S_2 (15 x 15 cm) also exhibited positive effects on bulb quality like bulb diameter (4.42 cm) and bulb weight (12.01 g), while yield (1.934 kg/plot and 59.20 q/ha) were recorded to be significantly the highest at spacing S_1 (15 x 10 cm). The P_2 S_3 recorded significantly higher bulb diameter (4.84 cm), weight of bulb (13.61 g). While, yield (2.341 kg/plot and 70.93 q/ha) were recorded to be significantly highest at P_2S_2. These findings provide valuable insights for garlic cultivation, helping farmers optimize planting strategies to enhance crop performance and yield.

Keywords: Planting time; spacing; garlic; bulb diameter; bulb weight; yield; sulphur content.

1. INTRODUCTION

Garlic (*Allium sativum* L.) is a significant bulb crop, second only to onions, and is believed to have originated from Central Asia and Southern Europe. It is grown in India on a large scale, with Gujarat, Madhya Pradesh, Maharashtra, Uttar Pradesh, and Rajasthan being major garlic-growing states. Garlic is known for its numerous medicinal properties and culinary uses, containing essential minerals, vitamins, and other beneficial substances [1,2,3]. The growth, yield, and quality of garlic bulbs are influenced by environmental factors and agricultural practices, such as planting time and spacing. Temperature, photoperiod, and soil conditions play crucial roles in garlic cultivation. Proper management of these factors is essential to optimize growth, maximize yield, and enhance the quality of garlic bulbs. Determining the ideal spacing between plants is crucial to achieving the best results. While wider spacing promotes larger bulb size, closer spacing increases overall yield by accommodating more plants per unit area. Additionally, selecting appropriate planting dates can significantly impact garlic's growth cycle and final yield. Research on specific planting time and spacing for garlic cv. Anand Kesari can provide valuable insights for farmers in Gujarat to enhance their garlic production.

2. MATERIALS AND METHODS

The field experiment was carried out during *rabi* season of the year 2022-23 at Horticulture Research Farm, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, Anand. It was laid out in Randomized Block Design concept (Factorial). The soil of the experimental plot was sandy loam type. There were three levels of planting time *viz.*, P_1 – 1st week of October, P_2 – 3rd week of October and P_3 – 1st week of November and three levels of spacing *viz.*, S_1 - 15 x 10 cm, S_2 – 15 x 15 cm and S_3 – 20 x 10 cm. Recommended dose of farm yard manure and NPK fertilizers were given as common dose in all the treatments.

2.1 Yield Parameters

The weight of bulb was taken in grams on average basis. Bulb diameter were taken with the help of vernier caliper in centimeters. Bulb yield was taken on plot basis and then converted into quintals per hectare.

2.2 Quality Parameters

Chemical analysis was done using the standard procedures. T.S.S (^{0}Brix) was recorded with Ernma pocket hand refractometer and the sulphur content of the bulb (%) was recorded using the Turbidimetric method with a Spectrophotometer.

3. RESULTS AND DISCUSSION

The planting time P_2 (3rd week of October) gave significantly highest bulb diameter (4.46 cm), which was found to be equal with the planting time P_1 (1st week of October) by recording the bulb diameter of (4.18 cm). The greater number of plant height and number of leaves, the larger bulb diameter. Similar results were reported by Nourbakhsh and Cramer [4] in onion and Saikia et al. [5], El-Magd [6] in broccoli.

The bulb diameter was found to be significantly highest at spacing S2 (15 x 15 cm) i.e. (4.42 cm), it was equal with the spacing S_3 (20 x 10 cm) *i.e.* (4.25 cm). Each plant in the crop that was more widely spaced out had plenty of space around it, which prevented it from competing with other plants for food and nutrients. As a consequence, each plant performed better in terms of its own personality. The findings align with those of Gaikwad et al. [7], Nasir [8], Kahsay et al. (2014), Misra et al., [9] and Chanu et al. [10] in garlic and Biru [11] in shallot. The interaction effect of planting time and spacing evidentiated significantly maximum bulb diameter in P1S2 (Planting in 1st week of October at spacing 15 x 15 cm) *i.e.* (4.84 cm), it was at par with P_2S_1

(Planting in 3rd week of October at spacing 15 x 10 cm) recording the bulb diameter of (4.79 cm) and P_2S_2 (Planting in 3rd week of October at spacing 15 x 15 cm) recording the bulb diameter of (4.27 cm).The significantly minimum bulb diameter was noted in P_1S_1 (Planting in 1st week of October at spacing 15 x 10 cm) *i.e.* (3.82 cm).

The planting time showed significant effect on the weight of bulb, the planting time P_2 (3rd week of October) gave significantly highest weight of bulb (12.29 g).

The increase in bulb weight might be due to better vegetative growth like plant height, number of leaves/plants there by increasing the sink size in terms of bulb size. Thus, robust growth leads to production of more leaves, which resulted in synthesis of more photosynthates and increased accumulation of carbohydrates and other metabolites which ultimately determined the weight of bulbs. These results are in conformity with the findings of Teshale and Tekeste [12], Negero [13], Savale et al. [14] in garlic. The weight of bulb was found to be significantly highest at spacing S2 (15 x 15 cm) being (12.01 g). This might be due that a plant would be able to get more nutrients and air space with a wider spacing or a lower plant density. The findings aligned with that given by Singh and Singh [15] and Poovamma et al. [16]. The interaction effect of planting time and spacing evidentiated significantly maximum weight of bulb in P_2S_3 (Planting in 3rd week of October at spacing 20 x 10 cm) *i.e.* (13.61 g), it was at par with P_1S_1 (Planting in 1st week of October at spacing 15 x 15 cm) recording the weight of bulb of (13.42 g). However, the minimum weight of bulb (9.58 g) was recorded in P_3S_1 (Planting in 1st week of November at spacing 15 x 10 cm). This might be as a result of the optimal plant densities and planting dates. Muhammad Jamroz et al. [17] in garlic.

The planting time P_2 (3rd week of October) gave significantly highest yield (1.93 kg/plot). Decrease in yield was observed in early planting which may be due to poor growth and development of plant. As yield potential of a plant depends upon the amount of vegetative growth made before bulbing commences. Number of workers reported the beneficial effects of date of planting in garlic on yield, viz. Savale et al. [18]. The yield was found to be significantly highest (1.95 kg/plot) at spacing S1 (15 x 10 cm). Similar results were reported by Mekonnen and Gadisa [19] and Hadiawati and Nazam [20] in garlic, Shock et al. [21] in onion. The most intriguing finding was that the bigger bulb size and better morphological character development at S2 (15 cm x 15 cm) spacing were unable to offset the yield decline caused by the decreased plant population per unit area, Kun et al. [22] (Planting time 1st week of November with spacing 20 x 10 cm). Higher yield in 3rd week of October and closer spacing is because of more plants per hectare and vigorous growth of plants in early planting dates, and it was noticed that yield decreased as the spacing between plants increased and delayed in planting. The observation is in agreement with the findings of Devulkar et al. [18], Vidya et al. [23] in garlic and Kahsay et al. [24] in onion.

Different planting time has a significant effect on the yield of garlic. Planting at P_2 (3rd week of October) showed significantly the highest yield (60.7 q/ha). The yield was found to be significantly the highest (59.2 q/ha) at spacing S_1 (15 cm x 10 cm) recorded the highest yield (t/ha), despite having low bulb weight, diameter, and cloves per bulb. Consequently, yield was lower at low plant populations due to narrow spacing. Moravcevic et al. [25] and Alam et al. [26] gave similar outcome that the production was best with the narrower planting, but the bulb quality was lowest.

The interaction effect of planting time and spacing depicted significantly maximum yield of garlic in P2S1 (Planting time at 3rd week of October with spacing 15x 10 cm) i.e. (70.93 q/ha), minimum yield (44.99 q/ha) was found in P3S2 (Planting time 1st week of November with spacing 15 x15 cm).

The effect of different time of planting time and spacing was found non-significant with respect to TSS and the interaction effect of different planting time and spacing was found non-significant with respect to Total Soluble Solids (TSS). The effect of different time of planting time and spacing was found non-significant with respect to sulphur content of the bulb and interaction effect of different planting time and spacing was found non-significant with respect to sulphur content of the bulb.

Table 1a. Effect of planting time and spacing on yield attributes of garlic

Treatment	Weight of bulb (g)	Bulb diameter (cm)	Yield (kg/plot)	Yield (q/ha)
Planting time (P)				
P_1 -1st week of October	11.14	4.17	1.73	54.43
P_2 - 3rd week of October	12.29	4.46	1.93	60.7
P_3 – 1st week of November	9.91	4.00	1.49	46.96
S. Em±	0.24	0.11	0.061	1.91
CD (P = 0.05)	0.72	0.33	0.182	5.72
Spacing (S)				
S_1 - 15 x 10 cm	10.08	3.96	1.95	59.2
S_2 - 15 x 15 cm	12.01	4.42	1.56	49.43
S_3 - 20 x 10 cm	11.25	4.25	1.65	53.46
S. Em±	0.30	0.11	0.061	1.91
CD (P = 0.05)	0.89	0.33	0.182	5.72
S. Em±	0.51	0.19	0.11	3.31
CD (P = 0.05)	Sig	Sig	Sig	Sig
CV (%)	8.57	7.87	10.60	10.60

Table 1b. Interaction effect of planting time and spacing on yield attributes of garlic

Spacing Planting time	Weight of bulb (g)			Bulb diameter (cm)			Yield (kg/plot)			Yield (q/ha)		
	S_1	S_2	S_1	S_2	S_3	S_1	S_1	S_2	S_1	S_2	S_3	S_1
P_1	9.75	13.42	10.25	3.78	4.79	3.93	1.91	1.74	1.54	57.8	55.36	50.13
P_2	10.91	12.34	13.61	4.26	4.27	4.84	2.34	1.48	1.98	70.93	46.93	64.25
P_3	9.58	10.26	9.89	3.82	4.19	3.98	1.61	1.45	1.42	48.87	46.01	46
S. Em±	0.41			0.19			0.11			3.31		
CD (P = 0.05)	1.24			0.57			0.32			9.91		
CV (%)	8.57			7.87			10.60			10.60		

Table 2. Effect of planting time and spacing on quality attribute of garlic

Treatment	TSS (˚ Brix)	Sulphur content of the bulb (%)
Planting time (P)		
P_1 -1st week of October	20.65	0.1331
P_2 - 3rd week of October	20.80	0.1339
P_3 – 1st week of November	19.58	0.1274
S. Em±	0.44	0.0024
CD (P = 0.05)	NS	NS
Spacing (S)		
S_1 - 15 x 10 cm	20.65	0.1339
S_2 - 15 x 15 cm	20.58	0.1320
S_3 - 20 x 10 cm	19.79	0.1285
S. Em±	0.44	0.0024
CD (P = 0.05)	NS	NS
P x S Interaction		
S. Em±	0.77	0.0042
CD (P = 0.05)	NS	NS
CV (%)	6.54	5.54

4. CONCLUSION

Based on the preceding analysis, it can be deduced that the optimal results for garlic cultivation were achieved by planting during the third week of October, which led to enhanced vegetative growth characteristics and greater yield. The utilization of a spacing configuration of 15 x 10 cm resulted in the highest yield due to the increased plant population per hectare. Consequently, the most favorable combination for maximizing yield without compromising quality involved the cultivation of the Anand Kesari garlic variety in the third week of October and spacing it at 15 x 10 cm

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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