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Effect of planting time and plant densities on yield, quality and cost of production in garlic (*Allium sativum* L.) cv. JAMNAGAR

G. VIDYA[1], M. PADMA AND M. RAJKUMAR[1]

Members of the Research Forum

Associated Authors:
[1]Vegetable Research Station, Agricultural Research Institute, Rajendranagar, RANGAREDDY (A.P.) INDIA

Author for correspondence :
M. PADMA
Vegetable Research Station, Agricultural Research Institute, Rajendranagar, RANGAREDDY (A.P.) INDIA
Email : masna_padma@yahoo.in

ABSTRACT : The effects of planting time and plant densities on yield per hectare, quality and cost of production were investigated in garlic (*Allium sativum* L.). Yield in garlic decreased significantly with delay in planting. Maximum yield (88.75 q/ha) was recorded in early planting on November 1st, while a progressive decrease under plant densities. Maximum yield (109.51 q/ha) was obtained with higher density treatment with 900 plants/plot spaced at 10 x 5cm. Maximum net returns of Rs. 1,30,382 per hectare recorded with 900 plants/plot with spacing of 10 x 5 cm but the highest benefit cost ratio (B: C ratio) was observed in 1st November planting with 300 plants/plot spaced at 20 x 7.5 cm (0.54:1). The quality parameters like TSS, reducing sugars, sulphur and ascorbic acid content were recorded at par in all the treatment combinations.

KEY WORDS : Garlic, Planting date, Plant densities, Yield, Quality, B:C ratio

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Garlic (*Allium sativum* L.) is an important bulb spice belonging to the family Alliaceae and the second most widely used cultivated bulb crops after onion. It is used both as a spice and vegetable commonly used in Andhra Pradesh having higher nutritive value than other bulb crops. It is rich in carbohydrates, proteins, phosphorous and ascorbic acid content. Garlic contains amino acid allin, which is colourless and odourless. When cloves are crushed, due to enzymatic reaction of allinase, allicin is converted into diallyl di sulphide gives true garlic odour (Shankaracharya, 1974). Garlic has several medicinal values. It reduces the cholesterol in the blood. Garlic juice is used in treatment of pulmonary tuberculosis, rheumatism, sterility, impotency, cough and red eyes (Pruthi, 1979). Garlic has lot of demand and is highly valued in the national and international markets due to its importance. It is known that among yield influencing factors under normal conditions, date of planting and plant density are the main factors which greatly influence the growth, yield and quality of garlic crop (Kilgori *et al.*, 2007). The present study was an attempt to identify suitable planting time and plant densities for successful production of garlic in this region.

RESEARCH METHODS

A field experiment was conducted during late *Rabi* season of 2011-2012 in Model Orchard, College of Horticulture, Rajendranagar, Hyderabad. There were four different dates of planting D_1 - 1st November, D_2 - 15th November, D_3 - 1st December and D_4 - 15th December and six plant densities, S_1 - 10 × 5 cm (900 plants/plot), S_2 - 15 × 5 cm (600 plants/plot), S_3 - 20 × 5 cm (450 plants/plot), S_4 - 10 × 7.5 cm (600 plants/plot), S_5 - 15 × 7.5 cm (400 plants/plot) and S_6 - 20 × 7.5 cm (300 plants/plot) were used as the treatments. The experiment was laid out in split plot design with 24 treatments replicated thrice. Recommended dose of fertilizers were applied at the rates of 125: 62.5 and 62.5 kg per hectare in the form of urea, single super phosphate and muriate of potash, respectively along with 25 tonnes of FYM. Before final land preparation, 50% of nitrogen and entire quantity of phosphorus and potash were applied as basal dose along with FYM and mixed thoroughly in the soil and remaining 50% of nitrogen was applied after four weeks of planting as topdressing. Wedding, irrigation and plant protection measured were taken up as and when required to keep the experiment free from weeds, pests and diseases and to maintain good health. The experimental plots were observed frequently to record changes in plant characters at different physiological stages of growth and data were recorded on yield, quality and cost of production. The data recorded were subjected to statistical analysis using split-plot design and ANOVA technique suggested by Panse and Sukhatme (1985).

RESEARCH FINDINGS AND DISCUSSION

Yield contributing characters like bulb weight, size of cloves and per cent of large bulbs recorded maximum with early date of planting and with lower density. But the yield was recorded maximum in early date of planting and in higher density due to more number of plants per unit area.

Yield:

The bulb yield of garlic was significantly influenced by different dates of planting. Crop planted on 1st November (D_1) recorded maximum bulb yield (88.75 q/ha) (Table 1) when compared to other dates of planting. Minimum bulb yield (64.21 q/ha) was recorded in 15th December planted crop. Yield was maximum in early planting which could be attributed to better growth of plants and large sized bulb and size of cloves resulted in increased sink capacity. Higher metabolism, greater photosynthates mobilization and better source sink relationship helped to produce higher yield. Size of bulb and bulb weight also might have influenced the bulb yield. The results are in conformity with Singh *et al*. (2010), Adekpe *et al*. (2008) in garlic

Plant densities showed marked effect in increasing the garlic yield which was evident from the fact that higher plant density with 900 plants/plot with spacing of 10 x 5 cm resulted in higher yield. At harvest, maximum yield of garlic (109.51 q/ha) (Table 1) was recorded with the plant density 900 plants/plot with spacing of 10 x 5 cm (S_1). Minimum yield/ha (57.41 q/ha) was recorded in crop with lower density of 300 plants/plot with spacing of 20 x 7.5 cm (S_6).

The total yield reduction could be due to decrease in plant population. The highest yield at high plant density levels can be attributed to compensatory effect of number of plants per unit area. The difference between the highest and the lowest population could be due to higher net assimilate obtained at higher population density per unit area. Increased productivity at higher plant population resulting from efficient utilization of resources and closer planting enabled maximum interception of radiant energy and conversion to biomass than wider spaced plants. These results are in accordance with the findings of Fikreyohannes Gedamu *et al*. (2008) and Castellanos *et al*. (2004) in garlic.

The interaction between dates of planting and plant densities significantly influenced the yield of garlic. Maximum bulb yield (134.30 q/ha) (Table 1) was recorded in D_1S_1 (1st November planting with 900 plants/plot spaced 10 x 5 cm), while minimum bulb yield (51.72 q/ha) in D_4S_6 (15th December planting with 300 plants/plot spaced 20 x 7.5 cm). The results are in accordence with Muhammad Jamroz *et al*. (2001) in garlic.

Quality parameters:

TSS:

Total soluble solids (TSS) differed significantly by different planting dates. Plants which were planted on November 1st recorded maximum TSS (26.64 Bº) (Table 1) while, minimum TSS (25.92 Bº) was obtained from the plants which were planted on December 15th. This might be due to vigorous vegetative growth and deep green color of foliage which favour higher photosynthetic activity of the plant. So, there was greater accumulation of food material *i.e*. carbohydrates in the bulb resulted in more synthesis of TSS. These results are in accordance with the findings of Singh *et al*. (2010), in garlic.

Plant density also showed significant differences in TSS in garlic. TSS recorded to be maximum (26.90) in closer spacing with higher density of 900 plants/plot with spacing of 10 x 5 cm (S_1). Minimum TSS was recorded (25.66) in wider spacing with lower density of 300 plants/plot with spacing of 20 x 7.5 cm (S_6). This might be due to minimal transpiration and respirational losses in closer spacing resulting in higher TSS. These findings are in confirmity with Shanthi and Balakrishnan (1989) in onion.

The interaction of dates of planting and plant densities significantly influenced the TSS. This might be due to the combination of planting dates and plant densities at optimum levels.

Sugars:

Total sugars, reducing and non-reducing sugars were significantly deferred with planting time but the results were at par in all the dates of planting.

Total sugars, reducing and non-reducing sugars deferred significantly with plant density. However, maximum values (0.068 mg/100g, 0.042 mg/100g and 0.026 mg/100g, respectively) (Table 1) were recorded in closer spacing with higher density of 900 plants/plot with spacing of 10 x 5 cm (S_1). Minimum values (0.062 mg/100g, 0.037 mg/100g and 0.024 mg/100g, respectively) were recorded with lower density of 300 plants/plot with spacing of 20 x 7.5 cm (S_6).

The interaction of dates of planting and plant densities significantly influenced the total sugars, reducing and non-reducing sugars. However, maximum values (0.078 mg/100g, 0.048 mg/100g and 0.029 mg/100g, respectively) (Table 1) were recorded in D_1S_1 (1st November planting with 900 plants/plot spaced 10 x 5 cm). Minimum value of total sugars (0.058 mg/100g) was recorded with D_4S_4 (15th December planting with 600 plants/plot spaced 10 x 7.5 cm), reducing sugars (0.034 mg/100g) was recorded with D_4S_2 (15th December planting with 600 plants/plot spaced 15 x 5 cm) and non-reducing sugars (0.021 mg/100g) was recorded with D_4S_5 (15th December planting with 400 plants/plot spaced 15 x 7.5 cm).

Sulphur content:

The sulphur content in bulb differed significantly due to different dates of planting. The 1st November (D_1) recorded maximum sulphur content (3.18 mg/100g) (Table 1) while, minimum sulphur content (3.14 mg/100g) was recorded in 1st December (D_3) planted plants. The sulphur content was found to be non- significant due to plant population. Interaction of dates of planting and plant densities was also showed non- significant to sulphur content.

Ascorbic acid content:

In present study, ascorbic acid content significantly differed due to dates of planting. However, crop planted on 1st November (D_1) registered significantly higher ascorbic acid (4.40 mg/100g) (Table 1) while it was lower (3.15 mg/ 100g) in crop planted late on 15th December (D_4). Among preharvest factors, light intensity and temperature are the most important in determining the final vitamin C content. Early sown crop has vigorous vegetative growth and deep green color of foliage favored higher photosynthetic activity of the plant. So, there was greater accumulation of food material *i.e.* carbohydrates in the bulb results in more

Table 1: Combined effect of planting date and plant densities on yield/ha, quality and cost of production in garlic

Treatments	Plant densities	Yield/ha (q)	TSS (B°)	T.S. (mg/100g)	R.S . (mg/100g)	N.R.S. (mg/100g)	Sulphur (mg/100g)	Ascorbic acid (mg/100g)	B:C.
Dates of planting									
1st November	10 × 5 cm (900 plants/plot)	134.30	27.17	0.078	0.048	0.029	3.21	4.33	0.48:1
	15 × 5 cm (600 plants/plot)	91.71	26.94	0.066	0.038	0.027	3.21	4.34	0.38:1
	20 × 5 cm (450 plants/plot)	69.11	26.77	0.066	0.039	0.027	3.21	4.40	0.28:1
	10 × 7.5 cm (600 plants/plot)	99.45	26.95	0.065	0.038	0.025	3.17	4.35	0.50:1
	15 × 7.5 cm (400 plants/plot)	74.46	26.04	0.062	0.034	0.026	3.15	4.48	0.51:1
	20 × 7.5 cm (300 plants/plot)	63.50	25.95	0.064	0.039	0.025	3.15	4.50	0.54:1
15th November	10 × 5 cm (900 plants/plot)	126.39	27.07	0.065	0.042	0.025	3.20	3.73	0.39:1
	15 × 5 cm (600 plants/plot)	87.10	26.78	0.065	0.037	0.025	3.18	3.96	0.31:1
	20 × 5 cm (450 plants/plot)	65.96	26.63	0.066	0.038	0.027	3.17	3.97	0.23:1
	10 × 7.5 cm (600 plants/plot)	93.42	26.75	0.063	0.038	0.026	3.13	3.93	0.41:1
	15 × 7.5 cm (400 plants/plot)	71.77	25.92	0.062	0.039	0.024	3.16	3.99	0.45:1
	20 × 7.5 cm (300 plants/plot)	61.48	25.88	0.065	0.040	0.025	3.13	4.06	0.49:1
1st December	10 × 5 cm (900 plants/plot)	97.93	26.77	0.064	0.041	0.025	3.16	3.44	0.08:1
	15 × 5 cm (600 plants/plot	71.09	26.41	0.061	0.037	0.026	3.12	3.49	0.07:1
	20 × 5 cm (450 plants/plot)	54.93	26.15	0.062	0.037	0.025	3.14	3.54	0.02:1
	10 × 7.5 cm (600 plants/plot)	78.14	26.43	0.061	0.036	0.025	3.14	3.53	0.18:1
	15 × 7.5 cm (400 plants/plot)	62.72	25.68	0.062	0.037	0.023	3.17	3.56	0.27:1
	20 × 7.5 cm (300 plants/plot)	52.93	25.44	0.061	0.037	0.024	3.13	3.61	0.28:1
15th December	10 × 5 cm (900 plants/plot)	79.42	26.58	0.064	0.038	0.026	3.19	3.08	-0.12:1
	15 × 5 cm (600 plants/plot)	67.47	26.12	0.060	0.034	0.023	3.12	3.09	0.02:1
	20 × 5 cm (450 plants/plot)	50.75	26.01	0.062	0.035	0.025	3.17	3.14	-0.06:1
	10 × 7.5 cm (600 plants/plot)	75.40	26.12	0.058	0.035	0.023	3.18	3.13	0.13:1
	15 × 7.5 cm (400 plants/plot)	60.51	25.41	0.060	0.037	0.021	3.18	3.19	0.22:1
	20 × 7.5 cm (300 plants/plot)	51.72	25.35	0.060	0.036	0.024	3.20	3.27	0.25:1
Interaction									
S × D	S.E.±	5.160	0.022	0.0016	0.0016	0.0010	0.031	0.218	
	C.D. (P=0.05)	10.430	0.44	0.0033	0.0032	0.0020	0.062	NS	
D x S	S.E.±	4.967	0.022	0.0016	0.0015	0.0010	0.030	0.225	
	C.D. (P=0.05)	10.251	0.046	0.0033	0.0032	0.0021	NS	0.477	

TSS- Total Soluble Solids, T.S- Total Sugars, R.S- Reducing Sugars, N.R.S- Non Reducing Sugars. NS=Non-significant synthesis of ascorbic acid content. These results are in accordance with the findings of Singh *et al*. (2010) in garlic.

The ascorbic acid content was found to be non-significant due to plant densities and interaction between dates of planting and plant population.

Cost of production:

Practicability of any technology is dependent on its technical feasibility and economic viability. Therefore, the identification of economically viable technology is of prime importance so as to recommend the same to the farmers for large scale adoption. The treatment combination of planting on 1st November and plant density with 900 plants/plot with spacing of 10 x 5 cm recorded highest yield (134.310 q/ha) and net returns (1,30,382 Rs./ha) (Table 1) over other treatment combinations. But, the highest benefit cost ratio (B: C ratio) was observed in 1st November planting with 300 plants/plot spaced at 20 x 7.5 cm (D_1S_6) (0.54:1) and least in 15th December planting with 900 plants/plot spaced at 10 x 5 cm (D_4S_1) (-0.12:1). In wider spacing, the cost of cultivation was less due to requirement of less seed material when compared to closer spacing hence the benefit cost ratio was high in wider spacing. This could be due to enhanced rate of seed material which will cost maximum for closer spacing while, it cost less for wider spacing. Ultimately the ratio of benefit cost ratio increased from closer spacing to wider spacing. Returns showed minus (-) trend in 15th December planting with plant population of 900 plants/plot spaced at 10 x 5 cm and with plant population of 450 plants/plot spaced at 20 x 5 cm because of lower returns when compared to cost of production which ultimately leading to loss in the treatment. The treatments 15th December planting with plant population of 900 plants/plot spaced at 10 x 5 cm and with plant population of 450 plants/plot spaced at 20 x 5 cm not at all feasible for cultivation.

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