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Original Research Article

Studies on Influence Response of Plant Density on Growth and Yield of Garlic (*Allium sativum* L.)

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A B S T R A C T

Field experiment was carried out to study the influence of plant density on growth and yield of garlic during *rabi* in 2015-16 was laid down in randomized block design on the farm of department of horticulture, college of agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.).The experiment was laid out in randomized block design with five treatments and four replications with the following plant densities: S_1 (15 x 2.5 cm), S_2 (15 x 5 cm), S_3 (15 x 7.5 cm), S_4 (15 x 10 cm) and S_5 (Broadcasting). Among the growth parameters and yield attributes, plant height, leaf length and bulb yield increasing significantly with the increasing level of plant density and these were maximum with S_1 (15 x 2.5 cm). However, the remaining growth parameters and yield attributes significantly increasing with decreasing plant densities. The growth parameters such as number of leaves per plant, leaf breadth significantly increasing with decreasing plant densities. The physiological parameters AGR, CGR are significantly increasing with S_4 (15 x 10 cm), S_2 (15 x 5 cm), S_3 (15 x 7.5 cm), S_5 (Broadcasting) and lowest in S_1 (15 x 2.5 cm). However, RGR at 30-60 days interval increasing with S_5 (Broadcasting), S_2 (15 x 7.5 cm) and lowest in S_1 (15 x 2.5 cm). Highest RGR at 60-90 days recorded in S_5 (Broadcasting) and lowest in S_4 (15 x10 cm). However crop duration not significantly affected by different plant densities of different plant spacing treatments.

Keywords

Spacing, Growth, AGR, SGR, CGR, Garlic

Introduction

Garlic (*Allium sativum var vulgare* L.) is one of the most important and widely consumed bulbous spice crops belongs to the family Alliaceae. West Asia and Mediterranean region is considered to be the centre of origin of garlic. It is cultivated throughout India for its bulb which forms an integral part of Indian culinary. The bulb can be consumed as spice or condiment in the form of garlic paste, pickle, chutney, curried vegetables, curry powders and meat preparation, *etc.* value added products of garlic are represented by garlic powder, flavours, flakes and volatiles. In *Unani* and *Ayurvedic* systems of medicine, garlic is used as carminative and gastri stimulant.

It helps in digestion and absorption of food. Allicin present in the aqueous extract of garlic reduces the cholesterol concentration in human blood. It is also used as vermifuge to expel worms and has long been recommended to cure number of ailments *viz.*, wounds, ulcer, pneumonia, bronchitis, dyspepsia and gastrointestinal disorders. (Ashgaripour and Arshadi, 2012) Spacing plays an important role in development of plants. Population of plants is dependent upon spacing. Plant spacing is very important factor in the cultivation of garlic crop. The spacing in garlic is crucial in obtaining better bulb yield without adversely affecting the quality. By spacing, the quality of bulbs, their size and shape can be improved readily but it still remains as a problem so to at what distance the maximum production and more nutritive value of garlic is obtained. (Singh and Singh, 2007)

Materials and Methods

A field experiment entitled "Studies on influence of plant density on growth and yield of garlic (*Allium sativumvar* L.)" was conducted at Department of Horticulture, VNMKV, Parbhani during winter (*rabi*) season of 2015-16. The details of the materials used and methods adopted during the course of investigation are described below.

Sowing

Healthy and bold garlic cloves of local cultivar separated from the bulbs were dibbled at different spacing apart in at 15 cm apart.

Results and Discussion

The results of the experiments conducted on Influence of plant density on performance of garlic (*Allium sativum* L.) are presented below.

Plant height (cm)

The data pertaining to plant height recorded at monthly intervals starting from 30 DAS as influenced by different plant densities and indicated significant differences among treatments (Table 2).

The plant height (cm) of the plant was increased subsequently at the growth stages i.e. 30, 60 and 90 DAS, but it was decreased at the harvesting stage during the year of experimentation. At 30 DAS higher plant height was recorded in S_1 (23.56 cm) followed by the treatment S_2 (22.73 cm) compared to the lowest S_5 (18.10 cm) *i.e.* broadcasting. Similar trend was observed up to harvest. At harvest, plant height ranged between S_1 (55.13 cm) and S_5 (40.49 cm). As the spacing was increased there was a reduction plant height. This may be due to availability of less per unit area due which more competition for light due to which more vertical growth occurred. These results are in agreement with the results obtained by Hussen *et al.,* (2014) on garlic reported that plant height was influenced by intra row spacing such that plant height increases when the intra row spacing of the plant decreases.

Number of leaves

The data pertaining to number of leaves recorded at monthly intervals starting from 30 DAS as influenced by different plant densities and indicated significant differences among treatments (Table 3).

Maximum no of leaves of the plant was increased subsequently at the growth stages i.e. 30, 60 and 90 DAS, but it was decreased at the harvesting stage during the year of experimentation.

At 90 DAS no of leaves was found to be maximum in S_4 (8.12) followed by S_3 (7.74) recorded and minimum in treatment S_5 (6.36). Similar trend was observed up to harvest. No of leaves per plant were found to be highest in wider spacing *i.e*. (15cm x 10 cm). As the spacing was reduced there was significant decrease in the number of leaf. Singh and Sachan (1999) also reported on garlic and onion that the greatest number of leaves per plant was found in the widest spacing. This could be partly due to the fact that wider spaced plants produce more axial branching than plants spaced at closer spacing.

Leaf length (cm)

The data pertaining to leaf length recorded at monthly intervals starting from 30 DAS as influenced by different plant densities indicated significant differences among treatments (Table 4).

Leaf length was found to be greatly influenced by the plant density. Among these leaf length was found to be highest in high plant density. Leaf length showed increasing trend when plant spacing decreased. The Leaf length (cm) of the plant was increased subsequently at the growth stages i.e. 30, 60 and 90 DAS, but it was decreased at the harvesting stage during the year of experimentation. Leaf length was found to be highest in S_1 (20.21 cm) at 30 DAS followed by S_2 (19.54 cm). At 90 DAS, the highest leaf length was recorded in S_1 (51.24 cm) which was at par with S_2 (48.37 cm) and the lowest was recorded in S_5 (37.48 cm).

Misra *et al.,* (2014) closer spacing had higher leaf length (47.95 cm), leaf area (83.63 cm), leaf area index (4.21), bulb dry matter (13.30%) and yield (253.40 q per hectare), while wider spacing had higher number of leaves (8.18), average single bulbs weight at harvest (56.24 g), polar diameter (4.79 cm) and equatorial diameter (49.39 mm).

Leaf breadth (cm)

The data pertaining to leaf breadth recorded at monthly intervals starting from 30 DAS as influenced by different plant densities indicated significant differences among

The Leaf breadth (cm) of the plant was increased subsequently at tgrowth stages i.e. 30, 60 and 90 DAS, but it was decreased at the harvesting stage during the year of experimentation.

At harvest the lowest leaf breadth was recorded in treatment S_1 (0.88 cm) while the highest leaf breadth was recorded in treatment S_4 (1.07 cm) which at par with S_3 (0.96 cm). This result may be attributed to the fact that wider plant spacing showed less competitive for resource and as a result leaves develop to larger size; this result was in conformity with findings of Misra *et al.,* (2014) on garlic.

Absolute growth rate (g.day^{-1})

The data pertaining to AGR recorded at monthly intervals starting from 30 DAS influenced by different plant densities indicated significant differences among treatments (Table 6).

At 30-60 days, the maximum AGR was recorded by the treatment S_4 (0.094 g.day^{-1}) which was followed by S_3 (0.087 g.day^{-1}) compared to the minimum recorded in S_5 (0.061 g.day^{-1}).

At 60-90 days highest AGR was recorded at S_4 (0.147 g.day^{-1}) followed by S_3 (0.129 g.day^{-1}) compared to the minimum recorded in S_5 (0.089 g.day^{-1}).

Crop growth rate (g.m^{-2}.day^{-1})

The data pertaining to CGR recorded at monthly intervals starting from 30 DAS as influenced by different plant densities indicated significant differences among treatments (Table 8).

Treatment details

Treatments	Plants Per Hectare
S1 : (15 cm x 2.5 cm)	(2666666 Plants/ hectare)
S2 : (15 cm x 5 cm)	(1428571 Plants/ hectare)
S3 : (15 cm x 7.5 cm)	(1000000 Plants/ hectare)
S4 : (15 cm x 10 cm)	(666666 Plants/ hectare)
S5: (Broadcasting)	(500-600 kg /hectare)

Table.1 Plant height (cm) of garlic as influenced by different treatments at various growth stages

Treatment	30 DAS	60 DAS	90 DAS	At harvest
S_1 (15x2.5)	23.56	35.82	57.65	55.13
S_2 (15x5)	22.73	34.84	53.43	52.61
S_3 (15x7.5)	22.19	33.38	47.16	46.25
S_4 (15x10)	21.28	30.80	46.92	45.21
S_5 (Broadcasting)	18.10	27.72	41.56	40.49
SE ±	0.72	1.25	0.93	1.09
CD at 5 %	2.23	3.84	2.86	3.38
G.M.	21.57	32.51	49.34	47.93

Table.2 No of leaves of garlic as influenced by different treatments at various growth stages

Treatment	30 DAS	60 DAS	90 DAS	At harvest
S_1 (15x2.5)	3.68	4.27	6.76	6.11
S_2 (15x5)	3.72	4.32	7.59	6.69
S_3 (15x7.5)	3.81	4.68	7.74	6.87
S_4 (15x10)	4.39	5.37	8.12	7.29
S_5 (Broadcasting)	3.71	4.08	6.36	5.46
SE ±	0.104	0.153	0.181	0.151
CD at 5 %	0.320	0.472	0.557	0.467
G.M.	3.86	4.54	7.31	6.48

Table.3 Leaf length (cm) of garlic as influenced by different treatments at various growth stages

Treatment	30 DAS	60 DAS	90 DAS	At harvest
S_1 (15x2.5)	20.21	32.34	51.24	50.22
S_2 (15x5)	19.54	31.54	48.37	47.34
S_3 (15x7.5)	19.12	30.63	41.57	40.34
S_4 (15x10)	18.62	27.54	40.91	38.85
S_5 (Broadcasting)	16.72	24.72	37.48	36.41
SE ±	0.501	0.920	1.05	0.927
CD at 5 %	1.54	2.83	3.25	2.99
G.M.	18.84	29.35	43.91	42.66

Table.4 Leaf breadth (cm) of garlic as influenced by different treatments at various growth stages

Treatment	30 DAS	60 DAS	90 DAS	At harvest
S_1 (15x2.5)	0.59	0.78	0.97	0.88
S_2 (15x5)	0.66	0.86	1.08	0.94
S_3 (15x7.5)	0.69	0.92	1.12	0.96
S_4 (15x10)	0.71	0.96	1.19	1.07
S_5 (Broadcasting)	0.62	0.81	1.05	0.91
SE ±	0.018	0.029	0.028	0.023
CD at 5 %	0.055	0.089	0.087	0.073
G.M.	0.65	0.86	1.08	0.95

Table.5 The data related to AGR recorded at different stages of crop growth as influenced by various plant densities is furnished in Table 6

Treatment	AGR ($g.day^{-1}$) DAS	
	30-60	60-90
S_1 (15x2.5)	0.068	0.092
S_2 (15x5)	0.078	0.104
S_3 (15x7.5)	0.087	0.129
S_4 (15x10)	0.094	0.147
S_5 (Broadcasting)	0.061	0.089
G.M.	0.079	0.112

Table.6 The data related to CGR recorded at different stages of crop growth as influenced by various plant densities is furnished in Table 8

Treatment	CGR ($g.m^{-2}.day^{-1}$) DAS	
	30-60	60-90
S_1 (15x2.5)	0.018	0.021
S_2 (15x5)	0.022	0.029
S_3 (15x7.5)	0.025	0.036
S_4 (15x10)	0.027	0.039
S_5 (Broadcasting)	0.015	0.019
G.M.	0.021	0.028

Table.7 The data related to RGR recorded at different stages of crop growth as influenced by various treatments is furnished in Table 9

Treatment	RGR ($mg. m^{-2}.day^{-1}$) DAS	
	30-60	60-90
S_1 (15x2.5)	0.004	0.007
S_2 (15x5)	0.006	0.007
S_3 (15x7.5)	0.006	0.006
S_4 (15x10)	0.005	0.006
S_5 (Broadcasting)	0.008	0.008
G.M.	0.005	0.006

Table.8 Garlic dry bulb yield (kg/plot) and yield (t/ha) influenced by different treatments

Treatment	Dry bulb yield (kg/plot)
S_1 (15x2.5)	2.22
S_2 (15x5)	2.04
S_3 (15x7.5)	1.88
S_4 (15x10)	1.76
S_5 (Broadcasting)	0.82
SE ±	0.065
CD at 5 %	0.200
G.M.	1.74

Table.9 Crop duration (days) influenced by different treatments

Treatment	Crop duration (days)
S_1 (15x2.5)	132.3
S_2 (15x5)	132.5
S_3 (15x7.5)	131.7
S_4 (15x10)	132.4
S_5 (Broadcasting)	131.2
SE ±	5.77
CD at 5 %	NS
G.M.	132.0

At 30-60 days, the maximum CGR was recorded by the treatment S_4 (0.027 g.m^{-2}.day^{-1}) which was followed by S_3 (0.025 g.m^{-2}.day^{-1}) compared to the minimum recorded in S_5 (0.015 g.m^{-2}.day^{-1}). At 60-90 days highest CGR was recorded at S_4 (0.039 g.m^{-2}.day^{-1}) followed by S_3 (0.036 g.m^{-2}.day^{-1}) compared to the minimum recorded in S_5 (0.028 g.m^{-2}.day^{-1}).

Relative growth rate (mg. m^{-2}.day^{-1})

The data pertaining to RGR recorded at monthly intervals starting from 30 DAS as influenced by different plant densities indicated significant differences among treatments (Table 9).

At 30-60 days, the maximum RGR was recorded by the treatment S_5 (0.008 mg. m^{-2}.day^{-1}) which was followed by S_2 (0.006 mg. m^{-2}.day^{-1}) compared to the minimum recorded in S_1 (0.004). At 60-90 days highest RGR was recorded at S_5 (0.008 mg. m^{-2}.day^{-1}) which was followed by S_2 (0.007 mg. m^{-2}.day^{-1}) compared to the minimum recorded in S_4 (0.006 mg. m^{-2}.day^{-1}) and S_3 (0.006 mg. m^{-2}.day^{-1}).

Dry bulb yield (kg/plot)

The data pertaining to dry bulb yield recorded at final harvest influenced by different plant densities indicated significant differences among treatments (Table 10).

There was significant difference for the bulb yield (kg/plot) as influenced by different plant densities (Table 10).

Highest bulb yield (kg/plot) was recorded by the treatment S_1 (2.22 kg) followed by S_2 (2.04 kg) compared to the lowest recorded in S_5 (0.82 kg).

Yield per plot was found to be highest in low spacing i.e. S_1 (2.22 kg) irrespective of low bulb weight, diameter and no of cloves per bulb. Whereas in treatment S_5 (broadcasting) yield was less (0.82 kg). The most interesting point to note was that at S_4 (15cm x 10cm) spacing the better development of morphological characters and larger size of bulb could not compensate by the reduction in yield due to lower plant population per unit area. The closest spacing have the highest yield with small bulb was reported by Kun *et al.,* (1999). Kumar *et al.,* (1998) also reported similar results by stating that closet plant spacing produces higher onion bulb yield.

Crop duration (days)

The data pertaining to crop duration recorded at final harvest influenced by different plant densities indicated significant differences among treatments (Table 11). Days to physiological maturity was not significantly influenced by plant spacing. There was no a significant statistical variation (p>0.05) in days to maturity between the different spacings reported by Muller and Crock (1998).

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