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Impact of planting methods and clove size on growth, yield and economics of garlic (*Allium sativum* L.) during *rabi* season

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Abstract
The field experiment was conducted at Saidapur Farm, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, on different planting methods and clove size on growth and yield of garlic during *rabi* (2016-17) season. The treatment consists of four different planting methods *viz*., flat bed, broad base furrow, ridges and furrow and dome shape method with three different clove sizes *i.e*., small (<0.75g), medium (075-1g) and large (>1g). Significant differences were observed among planting methods and the size of planting materials. Among the planting methods, dome shape method (P_4) was consistently superior for growth parameters with highest plant height (57.22 cm), number of leaves (6.97), leaf area (33.93 dm^2) during harvesting and was on par with BBF method. Whereas, broad base furrow (BBF) method recorded highest fresh weight (22.11 g), dry weight (11.54 g), dry matter accumulation (53.57 g), bulb weight (17.89 g), bulb diameter (38.05 mm), number of cloves (26.51), hundred clove weight (98.22 g), clove size (1.57 cm^2) and total bulb yield (9.88 t/ha) compared to other methods. Further, planting large clove was noticed to be superior for the plant height (56.80 cm), number of leaves (6.88), leaf area (28.61 dm^2), fresh weight (20.71 g), dry weight (10.22 g), dry matter accumulation (50.57 g), bulb weight (17.56 g), bulb diameter (36.51 mm), number of cloves (24.83), hundred clove weight (97.96 g), clove size (1.67 cm^2) and total bulb yield (9.72 t). The interaction effects were found significant for number of leaves, leaf area, fresh weight, dry weight, dry matter accumulation, number of cloves, hundred clove weight, clove size and bulb yield. However interaction effects were non significant for plant height. BBF method of planting with large clove (>1 g) was found to be superior over all the treatments as it resulted in better growth and higher yield with highest B:C ratio.

Keywords: garlic, *Rabi*, BBF, dome shape and yield

Introduction
Garlic (*Allium sativum* L.) is one of the important and widely consumed bulbous spice crops belonging to the family, *Alliaceae*. The economic yield is obtained from its underground bulb, which consists of bulblets, popularly called as cloves. It contains protein, phosphorus, potash, calcium, magnesium, carbohydrates and a colourless as well as odourless water soluble amino acid called allicin. On crushing the bulb an enzyme allinase acts upon allin and breaks down to produce allicin, the principal ingredient of which is odoriferous *diallyl-disulfide*, which is the major flavoring component in garlic. Land configuration (flat bed, broad base furrow, ridges and furrows and dome shape) also plays a major role in increasing the productivity of garlic. The raised bed zone of broad base furrow system was better with lower penetration resistance favorable for deeper seed placement and better crop emergence (Jayapaul *et al*., 1996) [6]. Ridge planting not only improved the yield but also the crop growth as compared to flat bed (Tomar *et al.*, 1996) [13]. The size of the bulbs harvested is directly related to the size of cloves planted. Besides its economic importance and other multiple advantages, productivity of the crop is very low because of inappropriate production technologies such as planting method, clove size, fertilization and pest and disease control. Thus, this research was initiated to address the low productivity of garlic by implementing appropriate planting methods and planting material.

Material and Methods
The field experiment was conducted at Saidapur Farm, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, during *rabi* (2016-17) season. The treatment consists of four different planting methods *viz*.

flat bed, broad base furrow, ridges and furrow, dome shape method with three different clove sizes *i.e.*, small (<0.75g), medium (075-1g) and large (>1g). Experiment was laid out in a split plot design with three replications. Individual plot size was 4 m X 2 m. The spacing used was 15 cm X 7.5 cm with a single clove per hill. To obtain uniform maturity, irrigation was stopped two weeks before harvesting. Nitrogen, phosphorus and potassium were applied in the form of urea, di-ammonium phosphate and muriate of potash, respectively at the rate of 125:62.5:62.5 kg NPK per hectare as per the package of practices. At the time of sowing, half the dose of nitrogen and full dose of phosphorus and potassium were applied as basal dose and mixed thoroughly in the soil. The remaining half dose of nitrogen was top dressed at 30 days after sowing. Bulbs were harvested when the leaves had turned pale green and started falling. Data were collected on plant height, number of leaves per plant, leaf area, fresh weight, dry weight dry matter accumulation, bulb weight, bulb diameter, number of cloves, hundred clove weight, clove size and total bulb yield.

Results and Discussion

The data revealed that planting method had significant effect on plant height, number of leaves per plant, leaf area, fresh weight, dry weight and dry matter accumulation (Table 1). The plant height (57.22 cm), number of leaves per plant (6.97) and leaf area (33.93 dm^2) was significantly highest in dome shape method of planting (P_4) which was *on par* with BBF method. However, BBF method recorded highest fresh weight (22.11 g), dry weight (11.54g), and dry matter accumulation (53.57 g) whereas, the minimum was recorded in flat bed method of planting. The increase in plant height, leaf number and leaf area with the dome shape method and BBF of planting might be due to the increased turgidity of plant cells which resulted in the expansion of cell wall and manifested in the increased lateral and linear dimensions of leaves. This resulted in the higher photosynthetic rate, higher dry matter accumulation in plant parts, increase in plant height and stem girth, maximum dry matter production, translocation of more and more photosynthates from source to sink and ultimately led to higher bulb yield. These findings were well documented by Singh and Tewari (1998) [11], Patil (1995) [10], Suresh (1997) [12] and Khalil *et al.* (2002) [7] in garlic. The results also revealed a significant influence of size of planting material on plant height, number of leaves, leaf area, fresh weight, dry weight and dry matter accumulation. Planting large clove (>1 g) resulted in maximum plant height (56.80 cm), number of leaves per plant (6.88), leaf area (28.61 dm^2), fresh weight (20.71 g), dry weight (10.22 g) and dry matter accumulation (50.57 g) followed by medium clove *i.e.*, 0.75-1g. While, the minimum was recorded in small clove. The increase in all these morphological characters due to mobilization of the greater quantities of reserve food materials present in the large sized cloves, resulting in the speedy and increased vegetative growth compared to the small sized cloves. This was in aggrement with the results reported by Ahmed *et al.* (2007) [1] and Castellanos *et al.* (2004) [2]. The interaction effect was found non significant difference for plant height. While, Planting in dome shape method with large cloves (P_4S_3) was noticed to be significantly maximum number of leaves per plant (10.83), leaf area (82.22 dm^2) however, planting in BBF method with large clove recorded highest fresh weight (23.67 g), dry weight (13.90 g) and dry matter accumulation (61.70 g) while, the minimum was recorded in flat bed with small clove (P_1S_1).

The different planting methods also revealed significant differences for yield parameters (Table 2) wherein BBF method of planting (P_2) resulted in significantly higher bulb weight (17.89 g), bulb diameter (38.05 mm) number of cloves (26.51), hundred clove weight (98.22 g), clove size (1.57 cm^2) and bulb yield (9.88 t/ha) followed by dome shape method. Lowest was recorded in flat bed method. The increase in yield parameters with the broad base furrow method of planting is attributed to increased dry matter production which inturn was responsible for the translocation of photosynthates from source to sink producing parts. Thus, due to higher photosynthates the bulb characters might have developed to the maximum extent and resulted in higher bulb yields. These findings are in consonance with the reports of Gethe *et al.* (2006) [4] in onion, Maheriya (2008) [9] in radish and Ingle *et al.* (2000) [5] in garlic. The size of planting material also showed significant differences in yield attributes wherein planting large clove (>1 g) resulted in higher bulb weight (13.24 g), bulb diameter (12.45 g), number of cloves (24.83), hundred clove weight (97.96 g), clove size (1.67 cm^2) and bulb yield (9.72 t/ha) followed by medium clove *i.e.*, 0.75-1 g. The increase in the bulb yield is mainly attributed to production of more number of leaves, higher leaf area, dry matter accumulation, bulb weight and bulb diameter increased significantly by planting large sized clove and further these treatments recorded significantly higher yield which indicated that these parameters had direct influence on yield potential. Similar trend was observed by Deka and Shadeque (1993) [3].

The interaction effects were found significant. Planting in BBF method with large cloves (P_2S_3) was noticed to be superior in terms of bulb weight (18.20 g), bulb diameter (46.86 mm), number of cloves (30.33), hundred clove weight (116.83 g) clove size (1.92 cm^2) and total bulb yield (10.82 t/ha).

The data on economics of garlic presented in Table 3. The BBF method with large clove (T_6) recorded the highest gross return (₹7,57,400/ha.) with highest net returns (₹ 6,60,195.5/ha.) and recorded the highest cost benefit ratio(6.8:1) followed by BBF method with medium clove (T_5) with the gross return (₹6,93,023.3/ha.) with the net returns (₹ 5,99,818.8/ha.) and cost benefit ratio (6.4:1). This clearly indicates that the BBF method with large clove was found to be technically feasible and economically viable. A similar trend was observed by Lallen *et al.* (1992) [8] and Castellanos *et al.* (2004) [2] in garlic.

BBF method of planting with large clove (>1 g) was found superior over all the treatments as it resulted in better growth and higher yield. In the light of the results obtained in the present investigation it could be concluded that garlic cultivation in broad base furrow method of planting with large clove is ideal for getting higher yield, gross and net returns.

Table 1: Plant height, number of leaves, leaf area, fresh weight, dry weight and dry matter accumulation of garlic as influenced by planting methods and clove size

Particulars	Plant height (cm)	Number of leaves	Leaf area (dm^2)	Fresh weight (g)	Dry weight (g)	Dry matter accumulation (g)
Planting methods						
P_1	50.86	5.97	14.50	16.50	6.94	39.82
P_2	55.73	6.42	21.16	22.11	11.54	53.57
P_3	55.04	6.16	16.81	18.28	8.23	43.72
P_4	57.22	6.97	33.93	20.28	8.75	47.54
S.Em ±	0.98	0.19	1.05	0.55	0.27	1.39
C.D. at 5%	2.93	0.57	3.15	1.65	0.81	4.18
Clove size						
S_1	53.29	5.88	16.29	18.29	7.55	42.85
S_2	54.05	6.37	19.90	18.88	8.83	45.08
S_3	56.80	6.88	28.61	20.71	10.22	50.57
S.Em ±	1.12	0.13	0.96	0.40	0.22	0.80
C.D. at 5%	3.44	0.40	2.95	1.22	0.69	2.47
Interaction						
P_1S_1	47.63	5.37	11.54	15.67	5.99	36.83
P_1S_2	49.27	6.10	13.91	16.50	6.56	39.30
P_1S_3	55.67	6.43	18.07	17.33	8.27	43.33
P_2S_1	55.47	6.10	17.31	20.67	9.40	47.37
P_2S_2	55.33	6.43	18.90	22.00	11.33	51.63
P_2S_3	56.40	6.73	27.26	23.67	13.90	61.70
P_3S_1	54.40	6.03	14.73	16.00	7.25	42.07
P_3S_2	53.87	6.10	18.19	17.67	8.20	42.63
P_3S_3	56.87	6.33	17.51	21.17	9.23	46.47
P_4S_1	55.67	6.03	21.59	20.83	7.57	45.13
P_4S_2	57.73	6.83	28.59	19.33	9.22	46.73
P_4S_3	58.27	8.03	51.61	20.67	9.46	50.77
S.Em ±	1.75	0.38	6.56	1.19	0.70	2.31
C.D. at 5%	NS	1.16	19.89	3.60	2.11	7.00

P_1: Flat bed method
P_2: BBF method
P_3: Ridges and furrow method
P_4: Dome shape method
S_1: Small clove (< 0.75 g)
S_2: Medium clove (0.75 to 1.0 g)
S_3: Large clove (> 1.0 g)

Table 2: Bulb weight, bulb diameter, number of cloves, 100 clove weight, clove size and yield of garlic as influenced by planting methods and clove size

Particulars	Bulb weight (g)	Bulb diameter (mm)	Number of cloves/bulb	100 clove weight(g)	Clove size (cm^2)	Yield (t/ha)
Planting methods						
P_1	14.69	31.46	19.28	78.33	1.16	7.04
P_2	17.89	38.05	26.51	98.22	1.57	9.88
P_3	15.58	33.16	21.88	80.22	1.41	8.68
P_4	16.26	33.72	22.96	88.44	1.43	8.71
S.Em ±	0.48	1.01	0.39	3.31	0.04	0.34
C.D. at 5%	1.44	3.03	1.17	9.91	0.11	1.03
Clove size						
S_1	14.46	32.33	20.55	72.63	1.10	7.33
S_2	16.29	33.46	22.59	88.33	1.41	8.68
S_3	17.56	36.51	24.83	97.96	1.67	9.72
S.Em ±	0.39	1.08	0.48	2.04	0.05	0.18
C.D. at 5%	1.20	3.33	1.47	6.29	0.16	0.55
Interaction						
P_1S_1	13.10	30.88	16.67	71.67	0.93	4.78
P_1S_2	14.57	31.73	21.00	75.00	1.14	7.55
P_1S_3	16.40	31.77	20.17	88.33	1.40	8.79
P_2S_1	17.80	31.89	23.87	80.17	0.97	8.91
P_2S_2	17.67	35.40	25.33	97.67	1.83	9.90
P_2S_3	18.20	46.86	30.33	116.83	1.92	10.82
P_3S_1	12.33	32.90	19.67	65.00	1.17	8.12
P_3S_2	16.40	33.07	20.70	87.33	1.39	8.56
P_3S_3	18.00	33.53	25.27	88.33	1.66	9.35
P_4S_1	14.60	33.64	22.00	73.67	1.31	7.53
P_4S_2	16.53	33.65	23.33	93.33	1.26	8.70
P_4S_3	17.63	33.87	23.53	98.33	1.70	9.91
S.Em ±	1.15	3.78	1.64	5.89	0.20	0.64
C.D. at 5%	3.50	11.48	4.98	17.87	0.60	1.94

P_1: Flat bed method
P_2: BBF method
P_3: Ridges and furrow method
P_4: Dome shape method
S_1: Small clove (< 0.75 g)
S_2: Medium clove (0.75 to 1.0 g)
S_3: Large clove (> 1.0 g)

Table 3: Economics of garlic as influenced by plantings methods and clove size

Treatments	*Kharif* season					*Rabi* season				
	Cost of cultivation (₹/ha)	Yield (t/ha)	Gross income (₹/ha)	Net returns (₹/ha)	B:C ratio	Cost of cultivation (₹/ha)	Yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
T_1	83732.5	4.05	243000	159267.5	1.90	88732.5	4.78	334366.7	245634.2	2.80
T_2	87732.5	4.39	263600	175867.5	2.00	92732.5	7.55	528348.2	435615.7	4.72
T_3	91732.5	4.78	287000	195267.5	2.13	96732.5	8.79	615305.7	518573.2	5.43
T_4	83204.5	5.91	354600	271395.5	3.20	88204.5	8.9	623700	535495.5	6.10
T_5	88204.5	6.25	374800	286595.5	3.25	93204.5	9.9	693023.3	599818.8	6.44
T_6	92204.5	6.89	413600	321395.5	3.49	97204.5	10.8	757400	660195.5	6.89
T_7	83968.5	4.98	298600	214631.5	2.56	88968.5	8.12	568633.3	479664.8	5.40
T_8	87968.5	5.06	303800	215831.5	2.45	92968.5	8.56	598863.6	505895.1	5.43
T9	91968.5	5.34	320200	228231.5	2.48	96968.5	9.35	654738	557769.5	5.82
T_{10}	84440.5	5.11	306600	222159.5	2.63	89440.5	7.53	526866.7	437426.2	4.91
T_{11}	88440.5	5.30	318000	229559.5	2.60	93440.5	8.70	609185.9	515745.4	5.50
T_{12}	92440.5	6.53	391600	299159.5	3.24	97440.5	9.91	693547	596106.5	6.15

T_1: Flat bed method + Small clove
T_2: Flat bed method + Medium clove
T_3: Flat bed method + Large clove
T_4: BBF method+ Small clove
T_5: BBF method+ Medium clove
T_6: BBF method+ Large clove
T_7: Ridges and furrow method + Small clove
T_8: Ridges and furrow +Medium clove
T_9: Ridges and furrow method+ Large clove
T_{10}: Dome shape method + Small clove
T_{11}: Dome shape method + Medium clove
T_{12}: Dome shape method + Large clove

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