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Morphological and quality attributes of garlic (*Allium sativum* L.) as affected by different planting methods

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Abstract

A two-year field study was carried to evaluate effect of planting methods on morpho-quality traits of garlic with randomized complete block design having four repeats and plot size of 3.0 m × 5.0 m. Recommended dosage of fertilizer i.e., 140-85-125 kg ha^{-1}NPK was used. Four treatments viz. P_1 = Flat sowing (Conventional) (R × R = 20 cm), P_2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P_3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge and P_4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed were studied. Results showed that all planting methods significantly affected the morpho-quality attributes of garlic than conventional planting. However, amongst planting P_3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge considerably produced highest values of plant height (61.23 and 56.35 cm), No. of leaves per plant (7.50 and 8.50), average bulb girth (4.24 and 3.87 cm), average bulb weight (54.88 and 52.62 g), clove size (1.66 and 1.68 cm^2), 100-clove weight (94.04 and 92.06 g), bulb yield (12520 and 12429 kg ha^{-1}). Though, P_3 = Ridge sowing (R × R = 75 cm) method produced total soluble solids (25.12 and 27.76 %), soluble proteins (10.40 and 11.52 mg g^{-1}), soluble sugar (18.84 and 20.57 %), total sugar (10.70 and 12.28 mg g^{-1}), total phenol (33.40 and 34.97 mg g^{-1}) and total flavonoid (1.56 and 1.68 mg g^{-1}) than rest of the planting methods. It was suggested that P_3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge should be used for better growth and yield performance and quality in garlic production.

Keywords: Garlic, Morphological, Planting methods, Quality

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Introduction

The bulbous spice crop known as garlic (*Allium sativum* L.) is one of the most significant and popular members of the Alliaceae family. Its subsurface bulb, which is made up of bulblets known as cloves, is where the commercial yield is found. It includes allicin, a colorless and odorless water-soluble amino acid, along with protein, phosphate, potassium, calcium, magnesium, and carbohydrates. The enzyme allinase reacts with allin when the bulb is crushed, causing it to break down and generate allicin, whose main element is the pungent diallyl-disulphide that gives garlic its distinctive flavour. Garlic yield is greatly influenced by the land's topography, including its large base furrow, flat bed, ridges and furrows, and dome form. Lower resistance to penetration was preferable for deeper seed germination and greater crop rise in the elevated bed zone of the broad base furrow system (Jayapaul et al., 1996). In comparison to flatbed planting, ridge planting increased both crop output and growth (Tomar et al., 1996). One of the most efficient methods for rationalizing irrigation water is cultivation. Wide furrows could enable water-saving irrigation while yet maintaining acceptable yield levels. Improving irrigation water management for local farmers is therefore urgently needed (Farrage, 1995; Kanwar & Akbar, 2013; Geries et al., 2015). Increasing the productivity and output of the garlic crop requires careful consideration of planting techniques and sowing dates (Kaur et al., 2022). The crop's yield is very poor due to ineffective production strategies, such as planting technique, clove size, fertilizer, and pest and disease management. The size of the cloves sown determines the size of the bulbs that are harvested. Inappropriate production strategies, such as planting technique, clove size, fertilizer, and plant protection strategies result in a crop with very poor output despite its economic significance and other numerous benefits (Malashri et al. 2020). It is also obvious from the study of Sarker et al. (2017) that onion yield and yield parameters were significantly affected by the planting method and management strategies. Therefore, goal of this research is to use appropriate planting techniques and planting materials to address the poor production of garlic. According to reports, raised bed techniques of cultivation can enhance per unit productivity while saving 20–34 percent of the water used for irrigation, 16-69 percent of the cost of planting, and reducing the need for human labor (Hossain et al., 2010). When the weather is wet, such as in the winter, raised beds that are 6 to 8 inches high will aid to increase water drainage in poorly drained soil (Hayslip et al., 1987).

Materials and Methods

Experimental site

A two years (2019 and 2020) field trial was conducted at a research farm of Vegetable and Oilseeds Section, Agronomic Research Institute, Faisalabad i.e., 184.9 m above sea level, 73.1 ºE longitude, and 31.4 ºN latitude. The soil in the experimental site was categorized as sandy loam (Table 1).

Table 1 An experimental site's soil analysis (0-15 cm)

Soil features	2018-19	2019-20
pH	7.54	7.48
EC (dS m^{-1})	1.51	1.46
Total Nitrogen (%)	0.07	0.05
Available Phosphorus (ppm)	8.6	7.9
Exchangeable Potassium (ppm)	245	225

Management practices

The trail was laid out in randomized complete block design (RCBD) with four repeats. Plot size of 3.0 m × 5.0 m was maintained. Seed bed was prepared according to the treatments of the study. Garlic variety G-1 was used a test material. Application of NPK fertilizers was used @ 140-85-125 kg ha^{-1}. All other management practices viz. irrigation, plant protections measures (weeds, insect and diseases) etc. were kept uniform in the study.

Agronomic parameters procedure

Twenty individual plants were chosen from every single treatment and their height was taken with the help of a meter rod then their number of leaves were counted and averaged. After harvesting of crop, 20 bulbs from each treatment were separated and their length was taken by measuring scale and averaged. Their girth and diameter were taken with the help of Vernier caliper and averaged. The bulb weight of 20 selected bulbs was taken on a digital weighing balance and averaged. After taking bulb weight cloves from each bulb were separated, counted, and then averaged. Garlic yield was taken from each plot with the help of weighing balance and converted to kg ha^{-1}.

Quality analysis

Using a digital Refractometer, the garlic bulb juice's TSS (total soluble solid) concentration was determined. Crude protein was determined by the Kjeldahl method to determine nitrogen and then crude protein by conversion factor of 6.25 (A.O.A.C., 2005). Total sugars and soluble sugars were determined by titration as described in A.O.A.C. (2005). Total phenolic contents were determined according to protocol described by Folin Ciocalteu method (Singleton & Rossi, 1965).1.5 ml of Na_2CO_3 (20 percent w/v) was added after the supernatant (1.0 ml) and FC reagent (0.5 ml each) had been blended at vertex. The combination was then heated for one minute at 100 C, set aside till cooling, and then a reading at 750 nm (absorbance) was recorded using a UV visible Spectrophotometer. Using the technique developed by Pourmorad et al. (2006) total flavonoids were measured. A colorimetric analysis of aluminum was used to calculate the total flavonoids. In this method, dry garlic was first dissolved in 60% ethanol, then 1 ml of this solution was transferred to a test tube, and 6 ml of a 5% potassium acetate solution were added. The absorbance at 415 nm was then measured using a spectrophotometer. Bors & Saran (1987) measured allicin; the change in concentration was detected at 412 nm using spectrophotometry.

Statistical analysis

All the recorded data were analyzed statistically by STATISTIX 8.1. A comparison of treatment's means was made by using Least Significant Difference (LSD) test at $p \leq 0.05$ (Steel et al., 1997).

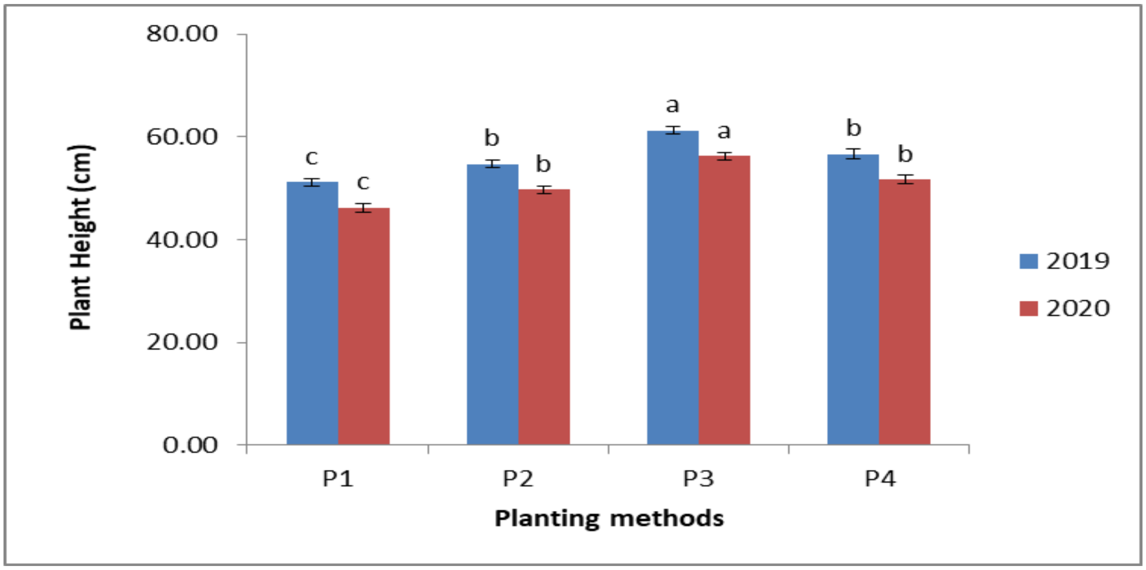
Results

Agronomic parameters

Planting techniques considerably ($p < 0.05$) affected the morphological attribute of garlic during both the years of trialing.

Plant height (cm)

It is obvious from the data presented in Fig. 1 that the maximum height (61.23 and 56.35 cm) of garlic plants was achieved at P_3 when garlic was planted on both sides of 75 cm apart ridges. Garlic planting methods (P_2 and P_4) statistically produced similar height of garlic plants. While the minimum garlic plants height (51.15 and 46.29 cm) was noted when garlic was sown on 20 cm apart rows (P_1 = conventional method).

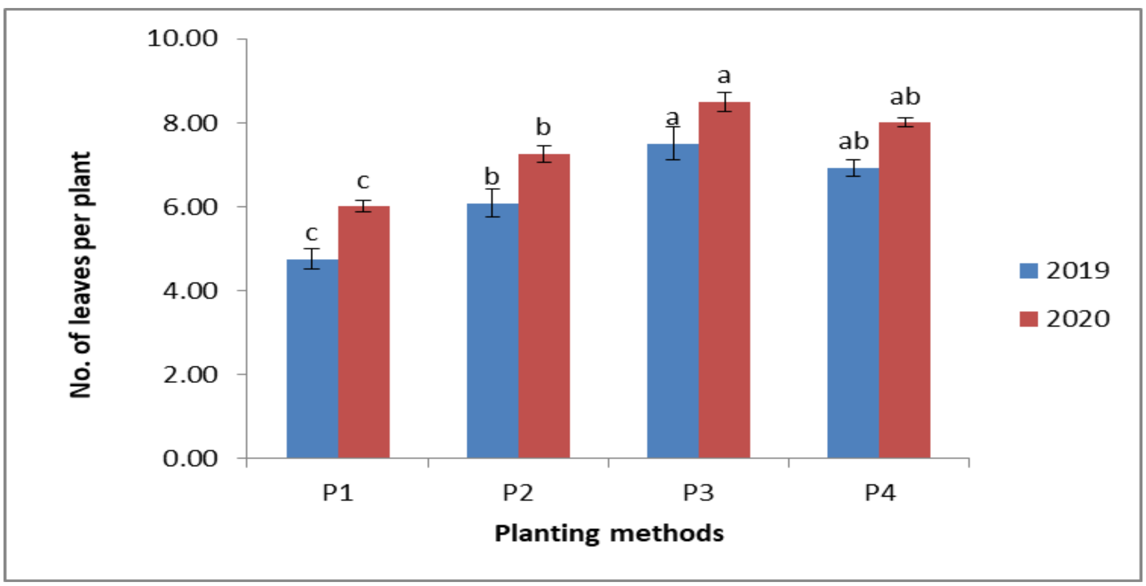


** Means sharing common letters do not differ at $P < 0.05$

Fig. 1 Plant height of *Allium sativum (garlic)* as influenced by various planting methods
(P1 = Flat sowing (Conventional) (R × R = 20 cm), P2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge, P4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed)

Number of leaves (per plant)

Number of leaves per plant in garlic was also significantly differing to each other when sown on different planting techniques (Fig. 2). During 2019 and 2020 maximum number of leaves per plant (7.5 and 8.5) in garlic was achieved in P_3 when garlic was planted on both sides of 75 cm apart ridges which was statistically at par with P_4 (Bed sowing (B × B = 150 cm)). Garlic sown under conventional planting technique (R × R = 20 cm) produced the lowest (4.75 and 6.0) number of leaves per plant in both the years.

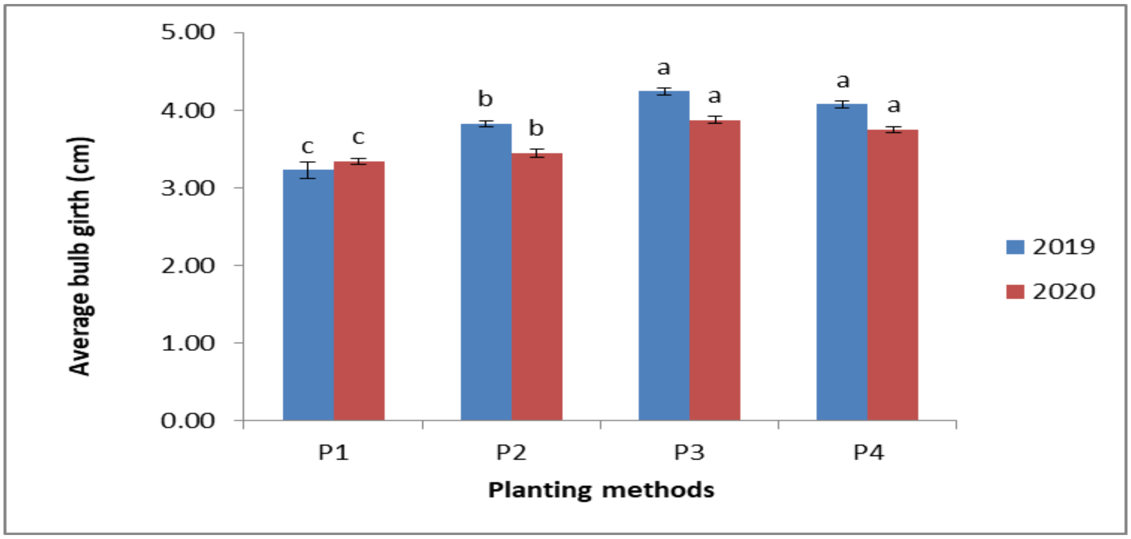


** Means sharing common letters do not differ at $P < 0.05$

Fig. 2 Number of plants per plant of *Allium sativum (garlic)* as influenced by various planting methods
(P1 = Flat sowing (Conventional) (R × R = 20 cm), P2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge, P4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed)

Bulb girth (cm)

Bulb girth of garlic was also significantly affected by various planting techniques in both the years of study (Fig. 3). Planting technique P_3 (garlic sown on both sides of 75 cm apart ridges) produced the highest bulb girth (4.24 and 3.87 cm) and P_1 (conventional planting with R × R = 20 cm) gave the lowest bulb girth (3.23 and 3.34 cm).

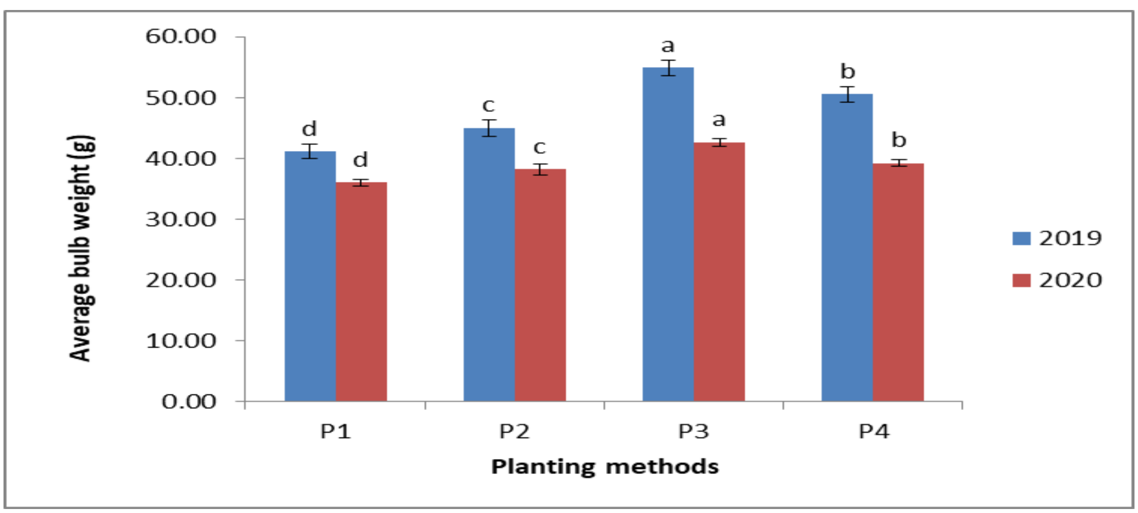


** Means sharing common letters do not differ at *P <0.05*

Fig. 3 Average bulb girth of *Allium sativum (garlic)* as influenced by various planting methods (P1 = Flat sowing (Conventional) (R × R = 20 cm), P2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge, P4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed)

Bulb weight (g)

Bulb weight is an important parameter for achieving good bulb yield. Different planting techniques under study during both the years 2019 and 2020 affected bulb weight ($p < 0.05$). It is well-defined from the presented data in Fig. 4 that maximum bulb weight (54.88 and 52.62 g) was given by garlic plants when sown with planting technique P_3 (garlic sown on both sides of 75 cm apart ridges) which was followed by garlic planted on beds (P_4) having bulb weight of 50.54 and 49.32 g, respectively in 2019 and 2020. On the other hand, the minimum garlic bulb weight (41.10 and 43.91 g) was noted in garlic when sown on 20 cm apart rows (P_1 = conventional method).

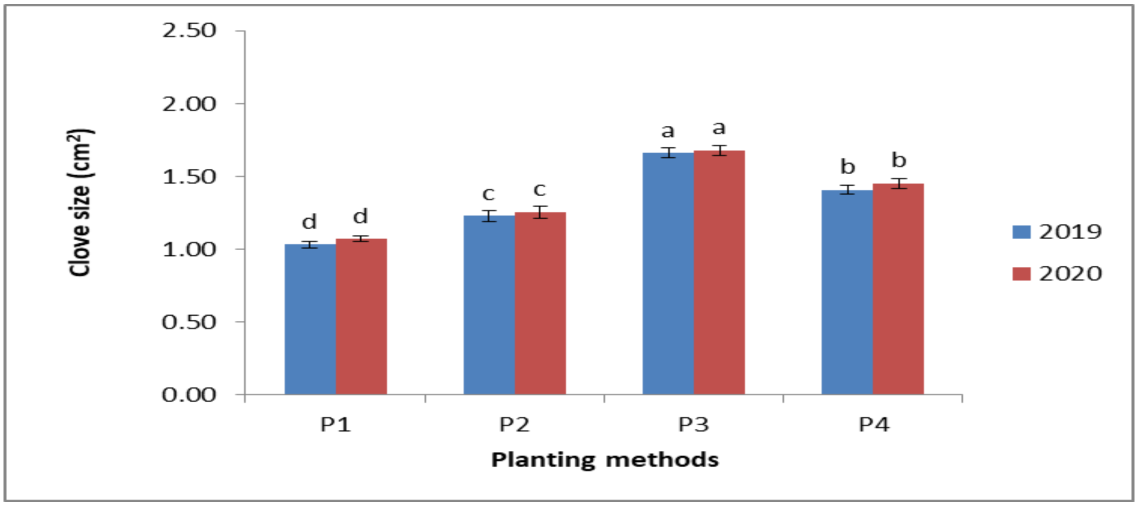


** Means sharing common letters do not differ at *P <0.05*

Fig. 4 Average bulb weight of *Allium sativum (garlic)* as influenced by various planting methods (P1 = Flat sowing (Conventional) (R × R = 20 cm), P2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge, P4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed)

Clove size (cm²)

Clove size of garlic plants was considerably deferring (*p <0.05*). to each other when garlic was sown by various planting techniques. Data regarding clove size (Fig. 5) clearly demonstrates that garlic planting on both sides of 75 cm apart ridges (P_3) produced the utmost clove size (1.66 and 1.68 cm²) followed by P_4 (Bed sowing i.e., B × B = 150 cm) with clove size of (1.41 and 1.45 cm²). Garlic sown with conventional planting technique (R ×R = 20 cm) shaped the lowest clove size (1.03 and 1.07 cm²) at *p <0.05*in 2019 and 2020.



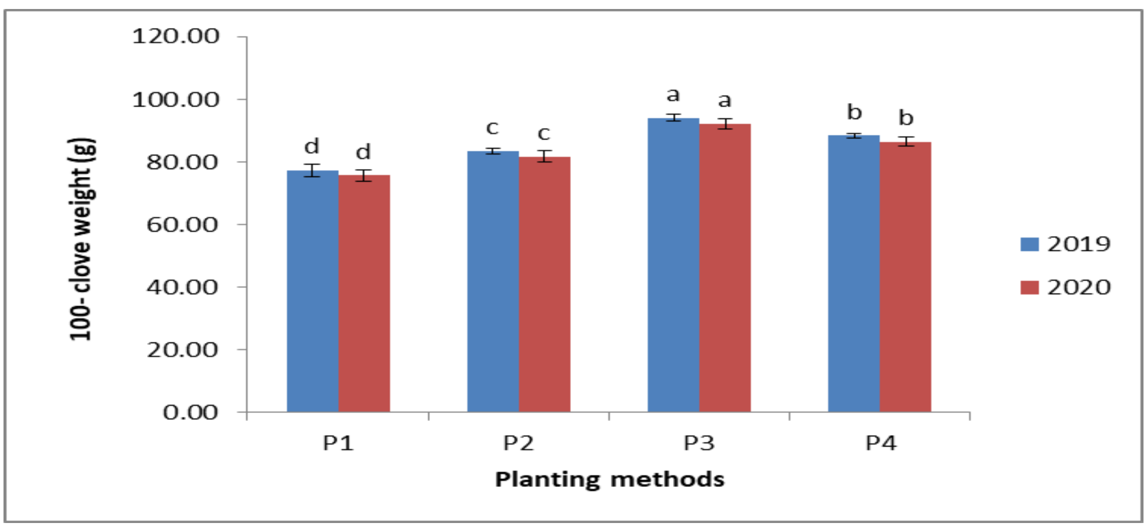
** Means sharing common letters do not differ at *P <0.05*

Fig. 5 Clove size of *Allium sativum (garlic)* as influenced by various planting methods

(P1 = Flat sowing (Conventional) (R × R = 20 cm), P2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge, P4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed)

100-clove weight (g)

During both the years of experimentation (2019 and 2020) different planting technique considerably affected the hundred clove weight at *p <0.05*(Fig. 6). Garlic sown on both sides of 75 cm apart ridges (P_3) fashioned the maximum 100-clove weight (94.04 and 92.06 g) followed by P_4 (Bed sowing i.e., B × B = 150 cm) with 100-clove weight (88.31 and 86.45 g). Conventional planting technique (P_1: R ×R = 20 cm) shaped the lowest 100-clove weight (77.29 and 75.67 g). The final economic yield of cops is of prime importance.



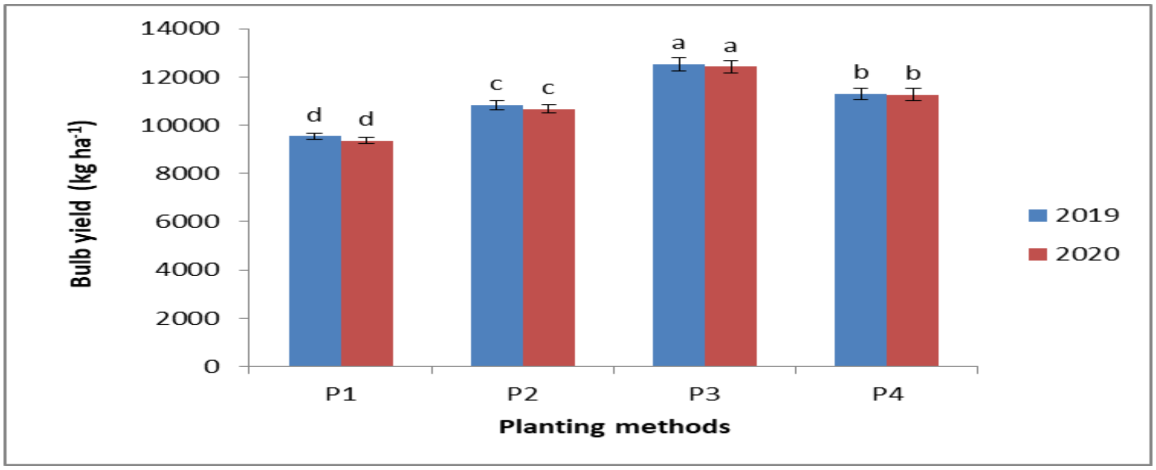
** Means sharing common letters do not differ at *P <0.05*

Fig. 6 100-clove weight of *Allium sativum (garlic)* as influenced by various planting methods

(P1 = Flat sowing (Conventional) (R × R = 20 cm), P2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge, P4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed)

Bulb yield (kg ha^{-1})

Various planting techniques under study in 2019 and 2020 substantially affected the bulb yield of garlic. Data given in (Fig. 7) indicates that planting of garlic on both sides of 75 cm apart ridges (P_3) shaped the maximum bulb yield (12520 and 12419 kg ha^{-1}) during both the years shadowed by P_4 (Bed sowing i.e., B × B = 150 cm) with bulb yield of (11300 and 11276 kg ha^{-1}). On contrary the minimum bulb yield (9539 and 9366 kg ha^{-1}) was noted when garlic was planted with conventional planting technique (P_1 = R ×R = 20 cm).



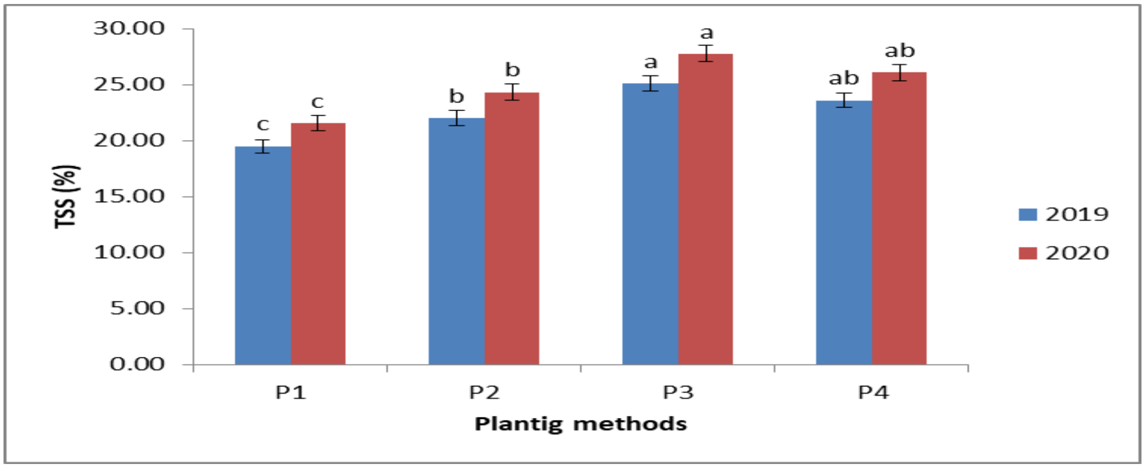
** Means sharing common letters do not differ at *P <0.05*

Fig. 7 Bulb yield of *Allium sativum* (garlic) as influenced by various planting methods (P1 = Flat sowing (Conventional) (R × R = 20 cm), P2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge, P4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed)

Quality parameters

Total soluble solids (TSS %)

Planting techniques under study also substantially affected the nutritive and quality attributes of garlic plants (Fig. 8). Presented data demonstrates that total soluble solids (TSS) were considerably varied *p (<0.05)* in different planting techniques of garlic. P_3 (garlic sown on both sides of 75 cm apart ridges) planting technique produced the highest total soluble solids (25.12 and 27.76%). Bed sowing of garlic (P_4) produced TSS (23.60 and 26.08%) which is statically equal to P_3. P_1 (conventional planting technique) gave the minimum total soluble solids (19.52 and 21.57%) in 2019 and 2020, respectively.

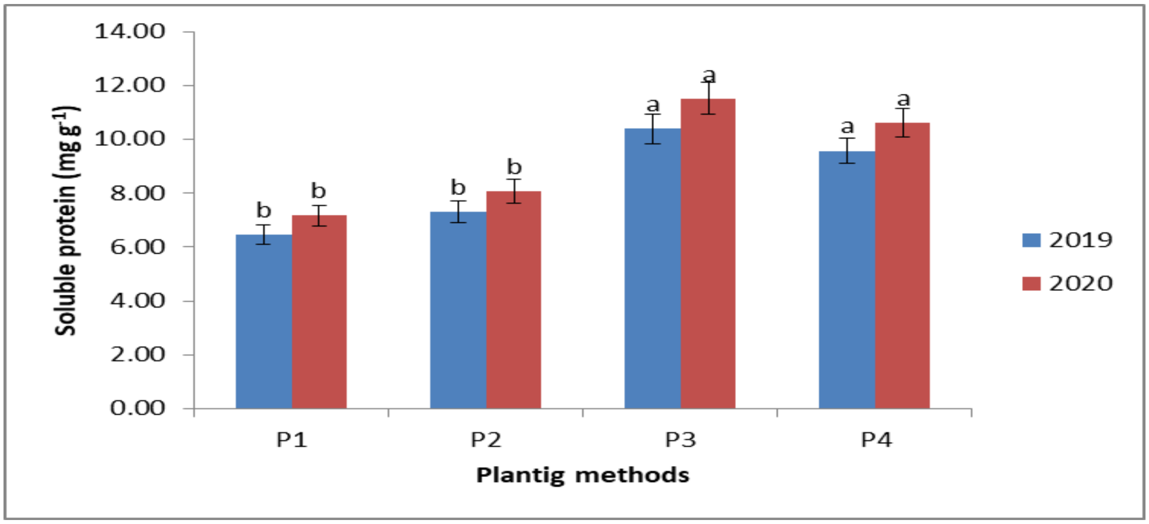


** Means sharing common letters do not differ at *P <0.05*

Fig. 8 Total soluble solids of *Allium sativum (garlic)* as influenced by various planting methods (P1 = Flat sowing (Conventional) (R × R = 20 cm), P2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge, P4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed)

Soluble proteins (mg g^{-1})

Considerable effect of planting techniques was observed *($p < 0.05$)* on soluble proteins (mg g^{-1}) of garlic. Data pertaining in Fig. 9 depicts that the utmost soluble protein (10.40 and 11.52 mg g^{-1}) in garlic was achieved when garlic was sown on both sides of 75 cm apart ridges (P_3) and on the contrary the minimum values (6.47 and 7.17 mg g^{-1}) of soluble proteins was noted in conventional planting technique (P_1 = R × R = 20 cm).

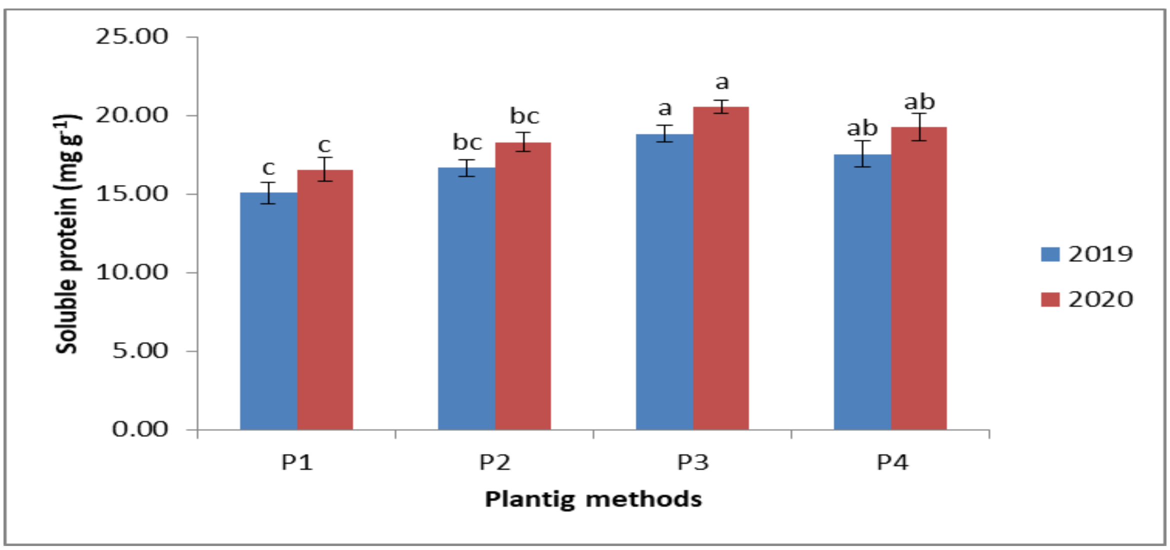


** Means sharing common letters do not differ at *$P < 0.05$*

Fig. 9 Soluble protein of *Allium sativum (garlic)* as influenced by various planting methods (P1 = Flat sowing (Conventional) (R × R = 20 cm), P2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge, P4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed)

Soluble sugars (%)

In garlic various planting techniques noticeably ($p < 0.05$) influenced the amount of soluble sugars. Results of this study (Fig. 10) showed that maximum (21.13 and 23.20%) soluble sugar was noticed in P_3 (garlic was sown on both sides of 75 cm apart ridges) planting technique. Bed sowing of garlic (P_4) produced SS (17.56 and 19.28%) which is statically equal to P_3. The lowest amount (15.08 and 16.56%) of soluble sugar was achieved in conventional sowing of garlic (P_1).

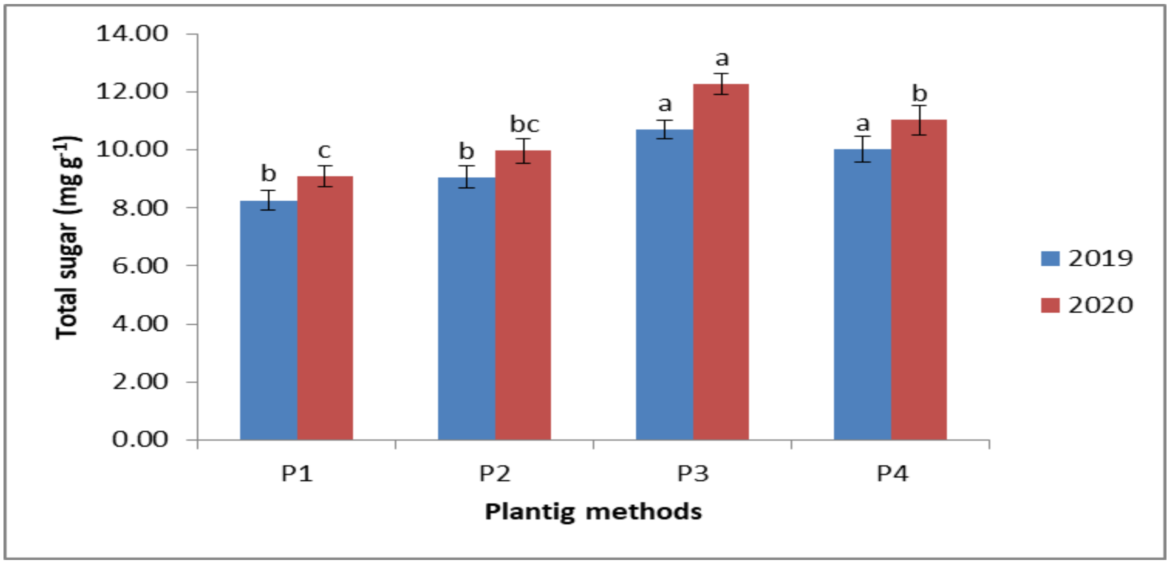


** Means sharing common letters do not differ at *$P < 0.05$*

Fig. 10 Soluble sugar of *Allium sativum (garlic)* as influenced by various planting methods (P1 = Flat sowing (Conventional) (R × R = 20 cm), P2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge, P4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed)

Total sugar (mg g^{-1})

In both the years i.e., 2019 and 2020 the quantity of total sugar greatly varied to each other *(p <0.05)* in different planting techniques (Fig. 11). The highest values (12.15 and 13.38 mg g^{-1}) of total sugar were noticed in in P_3 (garlic was sown on both sides of 75 cm apart ridges) and the lowest values (8.26 and 9.10 mg g^{-1}) was recorded in conventional planting technique (P_1 = R × R = 20 cm).

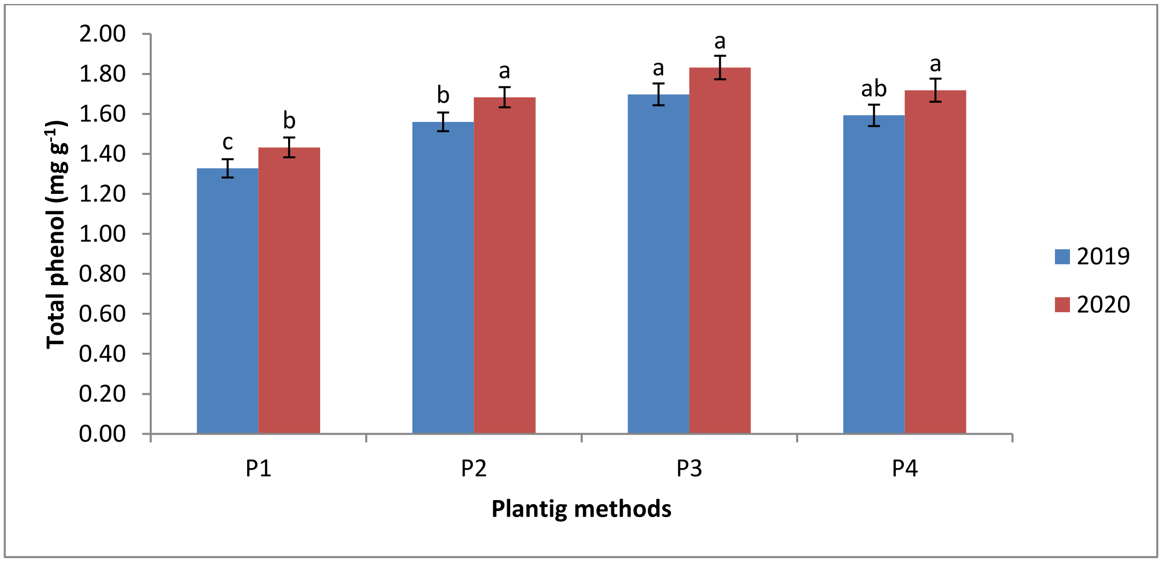


** Means sharing common letters do not differ at *P <0.05*

Fig. 11 Total sugar of *Allium sativum (garlic)* as influenced by various planting methods
(P1 = Flat sowing (Conventional) (R × R = 20 cm), P2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge, P4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed)

Total phenols (mg g^{-1})

As far as total phenols (mg g^{-1}) in garlic were concerned, the maximum (36.44 and 38.15 mg g^{-1}) total phenols (Fig. 12) were recorded when garlic was sown on both sides of 75 cm apart ridges (P_3) and the lowest (30.83 and 32.27 mg g^{-1}) total phenols was noticed in conventional planting technique (P_1 = R × R = 20 cm).

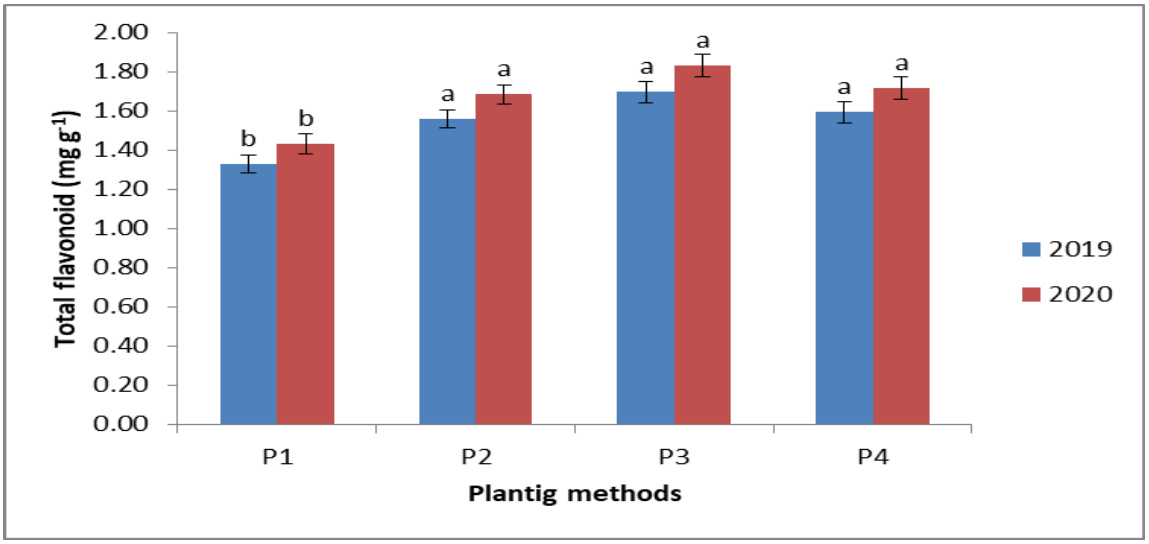


** Means sharing common letters do not differ at *P <0.05*

Fig. 12 Total phenols of *Allium sativum (garlic)* as influenced by various planting methods
(P1 = Flat sowing (Conventional) (R × R = 20 cm), P2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge, P4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed)

Total flavonoid (mg g^{-1})

Results regarding total flavonoid (Fig. 13) indicated that garlic was sown on both sides of 75 cm apart ridges (P_3) considerably produced the maximum (1.70 and 1.83 mg g^{-1}) and conventional planting technique ($P_1 = R \times R = 20$ cm) gave the minimum (1.33 and 1.43 mg g^{-1}) total flavonoid in garlic.



** Means sharing common letters do not differ at $P < 0.05$

Fig. 13 Total flavonoids of *Allium sativum (garlic)* as influenced by various planting methods (P1 = Flat sowing (Conventional) (R × R = 20 cm), P2 = Ridge sowing (R × R = 30 cm) one row on each side of ridge, P3 = Ridge sowing (R × R = 75 cm) two rows on each side of ridge, P4 = Bed sowing (B × B = 150 cm) eight rows on the top of bed)

Discussion

The second-largest Allium crop is garlic (*Allium sativum* L.). It is popular for its medicinal and dietary benefits in addition to being used often as a vegetable and condiment. The planting methods have a significant impact on garlic development because they encourage vegetative growth while enhancing bulb output with increased pore spaces and high aeration capacity. Planting methods considerably influence the various growth and developmental traits of garlic bulbs (Bayan et al., 2014).

In both seasons, there was a considerable disparity between all planting methods. When compared to alternative planting methods in both seasons, sowing garlic on both sides of 75 cm apart ridges resulted in the tallest plants with the most leaves, average girth, etc. It's possible that the broad furrows system's superiority in raising plant height is due to the fact that it makes it easier for plants to get adequate irrigation water than plants in tightly spaced ridges, resulting in better plant development and height. Farrage (1995), Kanwar & Akbar (2013), and Geries et al. (2015) among others, have all observed similar findings. The enhanced turgidity of plant cells, which resulted in the expansion of cell wall and expressed in the increased lateral and linear dimensions of leaves, might explain the rise in plant height and leaf number with the 75 cm apart ridges with garlic sowed on both sides. Greater photosynthetic rate, better accumulation of dry matter in plant segments, improved plant height and stem girth, maximum dry matter production, transfer of more and more photosynthates from source to sink, and eventually increased bulb output were the outcomes. Khalil et al. (2002), Singh & Tewari (1998), Patil (1995) and Suresh (1997) all documented these findings in garlic.

In terms of the impact of planting methods, there were substantial disparities in garlic planting methods in both growing seasons. The findings show that in the 2019 and 2020 seasons, planting in wide furrows (75cm apart ridges) was always linked with the highest overall bulb production and its components when compared to planting in closely spaced ridges (30 cm apart). Ahmed & Hassan (1978), Farrage (1995), Nawer (2006), Kanwar & Akbar (2013), and Geries et al. (2015) claimed similar conclusions. Added production of dry matter, which was accountable for the migration of photosynthates from source to sink regions, is also ascribed to the rise in yield characteristics using the broad base ridges technique of planting. As a result of the greater photosynthates, bulb characteristics may have evolved to their full potential, resulting in better bulb yields. Maheriya (2008) reported on radish, Gethe et al. (2006) reported on onion and Ingle et al. (2000) reported on garlic. The maximum bulb diameter, fresh weight, and dry weight were all considerably higher with the raised bed approach than with the flat bed method for producing cloves per bulb. This may be the case because, in contrast to flat sowing, bed sowing provides improved nutrient availability, better aeration, drainage, and an environment in which most bulbous crops can produce their bulbs efficiently. The results were in agreement with those of Kondiram et al

(2015); Kaur et al. (2017); Pratap et al. (2017). It is clear from the data in figures 8-12 that planting method had a significant impact on bulb quality in both growing seasons. The maximum values of, TSS%, soluble protein, total sugar, soluble sugar, total phenolics and total flavonoid were obtained by planting in planting in wide furrows (75 cm apart ridges) and the reverse was true for planting in ridges during both growing seasons. The flat planting approach yielded the lowest TSS, whereas the raised bed planting method generated the greatest TSS. This might be explained by the raised bed planting method's better soil moisture conditions, which lead to stronger vegetative development and higher photosynthetic activities, resulting in a bigger accumulation of food material and higher TSS content than with flatbed planting. These results are in line with the research on garlic by Katyal & Chandha (1997); Kotgirwar et al. (1997); Guljar et al. (2017).

Though, variations in climate, geography, and planting method meaningfully revise the bulb output and quality. In addition, the influence of planting method on garlic bulbs quality is poorly understood. This may be the result of the plant growing more effectively in terms of the accumulation of dry matter under ridge and furrow sowing, which may appropriately supply more photosynthates for root development. The results presented here were consistent with those found in onion by Gethe et al. (2006). However, different researchers also stated the effect of planting methods with transplanting dates and harvesting times etc. They argued that the decrease in T.S.S due to delaying transplanting date from 15th December to 1st January agreed with (Coolong & Randle, 2003), who found out that the soluble solid content of mature bulbs had a negative linear response to increasing temperature.These results are in general harmony with those gotten by Kandil et al. (2013); Kanwar & Akbar (2013); Bharti & Ram (2014).

Conclusion

In P_3 = [Ridge sowing (R × R = 75 cm) two rows on each side of ridge] there was a noticeable increase in plant height, the total number leaves, the weight of a hundred cloves, clove size, bulb weight, bulb yield, the total soluble solids, soluble protein, soluble sugar, total sugar, total phenolic and total flavonoid contents over the conventional method of planting (P_1). Keeping in view the findings of study it was suggested that amongst various planting techniques P_3 = [Ridge sowing (R × R = 75 cm) two rows on each side of ridge should be used for better morphological and quality attributes of garlic.

References

Ahmed, M. K., & Hassan, M. S. (1978). Effects of land preparation and planting method on onion (*Allium cepa* L.) production in the Sudan Gezira. *Acta Horticulturae*, *84*(3), 27–32.

O. A. C. (2005). Official Method of Analysis. 18th Edition, Method 935.14 and 992.24, Association of Officiating Analytical Chemists, Washington DC, USA.

Bayan, L., Koulivand, P. H., & Gorji, A. (2014). Garlic: A review of potential therapeutic effects. *Avicenna Journal of Phytomedicine*, *4*(1), 1-14.

Bharti, N., & Ram, R. B. (2014). Estimating variation in the production, quality and economics of onion in response to transplanting dates and sulphur fertilization. *European Academic Research*, *2*(4), 4831-4843.

Bors, W., & Saran, M. (1987). Radical scavenging by flavonoid antioxidants. *Free Radical Research*, *2*(4-6), 289-294.

Coolong, T. W., & Randle, W. M. (2003). Temperature influences flavor intensity and quality in 'Granex 33' onion. *Journal of the American Society for Horticultural Science*, *128*(2), 176-181.

Farrage, M. M. (1995). Influence of planting method and plant density on growth, yield and bulb quality of onion grown from sets. *Assiut Journal of Agricultural Sciences*, *26*(1),73-83.

Gethe, R. M., Pawar, V. S., Pathan, S. H., Sonawane, D. A., & Kadlag, A. D. (2006). Influence of planting layouts, irrigation regimes and fertilizers level on growth and yield of onion under micro-sprinkler. *Journal of Maharashtra Agricultural Universities*, *31*(3), 272–247.

Geries, L. S. M., Moursi, E. A., & Abo–Dahab, A. M. A. (2015). Effect of irrigation levels, cultivation methods and plant densities on productivity, quality of onion crop and some water relations in heavy clay soils. *Journal of Soil Sciences and Agricultural Engineering*, *6*(12), 1467–1495.

Guljar, J, S., Singh, S. S., Nagaich, K. N., Gurjar, P. K. S., & Singh, L. (2017). Effect of planting methods, oraganic nutrient sources and bio- fertilizers on bulb yield and quality of onion. *Plant Archives*, *17*(1), 439–444.

Hayslip, N. C., Gull, D. D., Guzman, V. L., Shumaker, J. R., & Sonoda, R. M. (1987). Bulb onion production in Florida. *FLCoop. Extension Services Bulletin*, pp: 238.

Hossain, M. I., Islam, M. S., Hossain, I., Meisner, C. A., & Rahman, M. S. (2010). Seeding performance of two wheel tractor operated bed planter for cereal crop establishment. *International Journal of Energy Machinery*, *3*(1), 63–69.

Ingle, M. B., Diware, D. V., & Dod, V. N. (2000). Quality and bulb yield of garlic as influenced by planting methods and spacing. *Crop Research*, *20*(1), 160–162.

Jayapaul, P., Kumar, B., Devasagayam, M., Panlan, B.J., Palchan, A., & Balkrishnan, A. (1996). Effect of land configuration methods, irrigation regimes, soil moisture conservation and amendments on soybean yield and quality characteristic. *Crop Research*, *10*(3), 253–257.

Kandil, A. A., Sharief, A. E., & Fathalla, F. H. (2013). Effect of transplanting dates of some onion cultivars on vegetative growth, bulb yield and its quality. *Crop Production*, *2*(3), 72–82.

Kanwar, M. S., & Akbar, P. I. (2013). Effect of planting methods on performance of onion varieties under cold desert conditions. *The Bioscan*, *8*(3), 911–913.

Katyal, S. L., & Chandda, K. L. (1997). Vegetable growing in India, Oxford and IBHZ publishing Co Pvt. Ltd. New Delhi, pp. 121–124.

Kaur, A., Sharma, M., Manan, J., & Bindu. (2017). Effect of method of sowing on bulb size and yield in garlic. *International Journal of Current Microbiology and Applied Sciences*, *6*(11), 5354–5357.

Khalil, F. A., El-Hamd A. S. A., Mohamed EI., & Hassan M. A. M. (2002). Response of onion crop var. Shandaweel 1 to some sources of organic fertilizers. *Journal of Agricultural Sciences*, *33*(5), 73–83.

Kaur, K., Kaur, A., & Singh, M. (2022). Effect of planting time and planting methods on the performance of garlic (*Allium sativum* L.) under Punjab conditions. *The Pharma Innovation Journal*, *11*(9), 2431-2435.

Kotagariwar, V. V., Choudhary, M. H., Damke, M. M., & Jadho, B. J. (1997). Effect of planting methods and clove size on growth, yield and quality of garlic (*Allium sativum* L) cv Godawari. *Punjabrao Krishi Vidyapeeth Research Journal*, *21*(2), 182–184.

Maheriya, P. A. (2008). Effect of land configuration and integrated nutrient management of growth, yield and quality of radish (*Raphanus sativus* L.) cv. PusaChetki. M.Sc. Thesis, Navsari Agricultural University (GAU), Navsari.

Malashri., Shashidhar, T. R., Neelambika, Anand, G., Patil., & Mangesh. (2020). Effect of planting methods on growth, yield and economics of garlic (*Allium sativum* L.). *International Journal of Chemical Studies*, *8*(3), 2902–2905.

Nawer, F. R. (2006) Effect of ridges width and plant density of onion on yield of intercropped sugar beet and onion. *Journal of Agriculture Sciences Mansoura University*, *31*(8), 4837–4847.

Pratapa, D., Padmab, M., & Sivasankarc, A. (2019). Influence of planting method, planting time and size of the planting material on yield and benefit: cost ratio of garlic cv. Jamnagar local. *Green Farming*, *10*(1), 11-16.

Patil, M. P. (1995). Integrated nutrient management in commercial vegetables (M.Sc. [Agri.] Thesis). University of Agricultural Sciences, Dharwad.

Pourmorad, F., Hosseinimehr, S. J., & Shahabimajd, N. (2006). Antioxidant activity, phenol and flavonoid contents of some selected Iranian medicinal plants. *African Journal of Biotechnology*, *5*(11), 1142–45.

Sarker, R., Ratna, M., Ray, S., Fahim, A. H. F., & Tithi, M. J. (2017). Effect of planting method on onion (*Allium cepa* L.) bulb production in Faridpur region of Bangladesh. *Archives of Agriculture and Environmental Science*, *2*(2), 63–67.

Singh, J. R., & Tewari, J. (1968). Effects of source of organic manures and levels of nitrogen on growth characteristics of *Allium Sativum* L. (Garlic). *Indian Journal of Horticulture*, *25*(3-4), 191-195.

Singleton, V. L., & Rossi, J. A. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American Journal of Enology and Viticulture*, *16*(3), 144-158.

Steel, R. G. D., Torrie, J. H., & Dickey, D. A. (1997). Principles and procedures of statistics: A biometrical approach. 3rd Edition, McGraw Hill Book Co. Inc. New York.

Suresh, M. J. (1997). Growth, yield and quality of garlic (Allium sativum L.) as influenced by spacing and manures. (M.Sc. (Agri.) Thesis). University of Agricultural Sciences, Dharwad.

Tomar, S. S., & Tembe, G. P. (1996). Improvement of physical conditions of black soils in Madhya Pradesh. Technical Bulletin, Department of Agri. Chem. and Soil Science, JNKVV, Jabalpur, 48–65.