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Kawaljit Kaur
Department of Vegetable Science, Khalsa College, Amritsar, Punjab, India

Amandeep Kaur
Department of Vegetable Science, Khalsa College, Amritsar, Punjab, India

Mandeep Singh
Department of Vegetable Science, Khalsa College, Amritsar, Punjab, India

Corresponding Author:
Kawaljit Kaur
Department of Vegetable Science, Khalsa College, Amritsar, Punjab, India

Effect of planting time and planting methods on the performance of garlic (*Allium sativum* L.) under Punjab conditions

Kawaljit Kaur, Amandeep Kaur and Mandeep Singh

Abstract
Planting methods and sowing time play important role in increasing the yield and production of garlic crop. A field experiment was conducted at Vegetable Research Farm, Department of Agriculture, Khalsa College, and Amritsar during the year 2020-21 to investigate the effect of planting time and planting methods on the performance of garlic (*Allium sativum* L.) under Punjab conditions. Eight treatments with three replications were designed to conduct the research. The obtained results showed the significant synergistic effect of planting methods with early date of sowing on the growth, yield and quality of garlic as over the flat planting method with late sowing date. Better vegetative and yield characters were observed in the raised bed method as compared to flat method. Planting time 10th September also gave best result which was at par with 20th September.

Keywords: Garlic, planting time, planting method, bulb yield and quality

1. Introduction
Garlic, scientifically known as *Allium sativum* L., is the second most popular *Allium* after onion. It is a flowering plant of the Alliaceae family with the chromosome number 2n=16 (Rubatzky and Yamaguchi 1997) [27]. *Allium sativum* gets its name from the Celtic word "ali," which means "burning" or "stinging," and the Latin word "*sativum*," which means "placed or cultivated (Tyagi *et al*. 2013) [34]. Planting methods have been shown to have a significant and positive impact on crop production, particularly by improved soil properties and providing a suitable seed bed for good seed germination, ease of emergence, good seedling establishment through enhanced root growth by encouraging vertical and horizontal root proliferation, and reduction in soil strength in the sub soil (Awe and Abegunri 2009) [4]. Raised beds are a common planting method for vegetable crops to increase yield. Ingle *et al*. (2000) [11] also reported a variation in crop yields based on the planting method used.
Garlic growth is mostly affected by the time of planting, since a short photoperiod and low temperature encourage vegetative growth, whilst a long photoperiod and high temperature encourage bulb production. The garlic bulb's growth and development are influenced by the date of sowing and the age of the plant (Atif 2020) [3]. Garlic productivity is impacted by planting choices, according to Geremew *et al*. (2010) [7]. Planting period, according to Murmu *et al*. (2019) [21], is a critical aspect that influences garlic development and output. Early garlic planting resulted in huge bulbs, which resulted in higher weight. Therefore, this study aims to evaluate the effect of planting time and planting methods on garlic performance.

2. Material and Methods
The present investigation was conducted in the Vegetable Research farm, Amritsar during the years 2020-21 using the cultivar PG-18. The experiment was laid out in Factorial Randomized Block Design with three Replications. The experiment was carried out with four different planting times, *et al*. 10th September (D_1), 20th September (D_2), 1st October (D_3) and 11th October (D_4) and two planting methods, namely raised bed method (M_1) and flatbed method (M_2). The performance of garlic was studied and data recorded on the days to 50% emergence, plant height (cm), leaves per plant, leaf length (cm), days taken to harvest, bulb diameter (cm), bulb yield kg/plot or q/ha), bulb fresh weight (g), bulb dry weight (g), dry matter content (%) and TSS (°Brix). The mean data was subjected to analysis following the analysis of variance technique of Panse and Sukhtame (1985) [22].

3. Result and Discussion

3.1 Effect of planting time on growth, yield and quality traits of garlic

The findings to Table 1,2 of the present experiment revealed a significant effect of planting time and methods on the days to 50% emergence, number of leaves per plant and plant height, maximum leaf length, days taken to harvest, bulb diameter, bulb fresh weight and bulb dry weight, bulb yield, dry matter content and TSS. The early date of sowing (10th September) were the most successful in reducing number of days to emergence while plants sowed on 11th October had the highest number of days to emergence. This might be due to the high temperature during early sowing date. Late emergence was observed as a result of planting on D_4 (11th October) was due to low temperature for germination. The results are in agreement with Jamroz *et al.* (2001) [13] and Zohiri *et al.* (2014) [36]. The highest numbers of leaves, leaf length and maximum plant height were recorded at early date of planting (10th September) while lowest number of leaves, leaf length and plant height was recorded at late planting date (11th October). This might be due to the higher metabolic activity because of early date of sowing encourage meristematic elongation and cell division which promote the vegetative growth of the plants, which helped in the synthesis of more photosynthates and thus resulting in increased accumulation of carbohydrates. The late planting crop (11th October) made poor vegetative growth resulted in decreased the height of garlic plants. The beneficial influence on plant height due to early planting has been reported by Rahim *et al.* (1984) [26], Qaryouts and Kasarawi (1995) [24], Sultana *et al.* (1997) [37] and Youssef *et al.* (2014) [35]. The result shows that planting garlic on 10th September mature early. While number of days taken to harvest was maximum when garlic was planted on 11th October. These results are accordance with Jamroz *et al.* (2001) [13] who also found that early planting dates taken minimum days compared to later planting of garlic. The highest bulb yield per plot and quintals per hectare was obtained from 10th September and lowest yield was found from the planting of October. It was revealed that the maximum yield was recorded at D_1 (10th September). However, the minimum yield was recorded at D_4 (11th October). The higher yield obtained from the early planting was probably due to the production of large bulb. In early planting, plants attained higher vegetative growth which possibly led to the development of larger bulb and higher yield which might have resulted in efficient metabolism thereby increased the sink capacity. Late planting produced smaller bulbs and lower yield may be explained in a way that the plants did not get a long cool growing period which was essential for proper development of vegetative growth for garlic. Rahim *et al.* (2003) [25], Singh *et al.* (2010) [31], Adekpe *et al.* (2008) [1] and Vidya Gunda (2015) [8] in garlic also reported that the early planting results in higher yield compared to later plantings. More number of cloves per bulb, maximum bulb diameter was recorded from 10th September. However, the lowest numbers of cloves minimum bulb diameter were recorded from D_4 (11th October). These results are in agreement with Schaffer (1985) and Jamroz *et al.* (2003) who recorded that bulb from early plantings contained more cloves and have more weight. Our findings were supported by Siddique and Rabbani (1985) [33], Ahmad *et al.* (2016) [39] who found that number of cloves per bulb decreased as sowing was delayed in the season. This could be due to the fact that the earlier planted crop had better vegetative growth because it had more time to grow under favorable climatic conditions, which ultimately resulted in the production of bulbs with larger cloves. Our findings were supported by Caruso and Anna (1995) [5] and Ahmad *et al.* (2017) [38] who reported that garlic bulb diameter decreased with planting time delay and that early planting resulted in the largest bulb diameter. The data revealed that the maximum fresh bulb weight and dry weight was obtained when the crop was planted on September 10th. The increase in bulb fresh weight and dry weight could be attributed to vigorous growth in garlic, which resulted in the synthesis of more photosynthates of more leaves, resulting in an increased accumulation of carbohydrates and other metabolites, which ultimately determined the weight of bulbs. Late planted crops produced vegetative growth, resulting in reduced photosynthetic activity due to less foliage area, which may have resulted in lower bulb weight. These results are in conformity with the findings of Rahim *et al.* (1984) [26], Singh *et al.* (2010) [31] in garlic, Izquierdo *et al.* (1981) [12] in onion that whose results also supported that early planting result in higher bulb weight. Jones and Mann (1963) [14] confirmed our findings by observing that the dry weight of garlic cloves decreased as planting time increased and increased as planting time decreased. The highest TSS was recorded from D_1 (10th September) while the lowest TSS was measured from D_4 (11th October). This could be due to the vigorous vegetative growth and the imparted deep green colour foliage, which favours higher photosynthetic activity of the plants, resulting in more TSS synthesis and improved bulb quality. The decrease in onion bulb quality caused by delaying sowing date was confirmed by (Coolong and Randle, 2003) [6], who discovered that the soluble solid content of mature bulbs had a negative linear response to increasing temperature. The present trend of increase in TSS of garlic bulb with the early date of sowing is in close conformity with the findings of Singh *et al.* (2010) [31]. The effect of planting time on dry matter content was found to be non-significant.

3.2 Effect of planting methods on the growth, yield and quality traits of garlic

The data showed in Table 1, 2 that the raised bed method took the fewest days to emergence of seedlings compared to the flat bed method. This could be due to the loose soil and favourable soil moisture and higher soil temperature conditions present in the raised bed method, which resulted in the seedling emerging from the soil more easily and earlier than in the flat bed planting method. During the research trial, Pratap (2014) [23] discovered that the ridge and furrow method of planting was consistently superior for 50 percent sprouting character over the flat bed method of planting. The raised bed method consistently produced significantly more leaves, maximum leaf length and plant height at all stages of plant growth and yielded the highest number of leaves per plant, leaf length and plant height followed by the flat bed method. This could be attributed to increased photosynthetic rate, increased dry matter accumulation in plant parts, increased plant height and stem girth, maximum dry matter production, and the translocation of more and more photosynthates from source to sink relationship. The current trend of increasing the number of garlic leaves per plant using the raised bed planting method is sconsistent with the findings of Haque *et al.* 2002 [10], Singh and Khalil *et al.* (2002) [17]. According to Haque *et*

al. (2002) [10], garlic sown on ridges produced the highest plant height; similarly, Singh and Singh 1995 [32], Sarkar *et al.* (2017) [28] and Sharma *et al.* (2009) [30] discovered that the raised bed method produced better onion performance than the flat bed method and the findings of Kondiram *et al.* (2015) [18], who discovered that the raised bed method had greater leaf length than the flat bed. The raised bed method required the minimum days to harvest while the flat bed method bulbs took maximum days for harvest. This could be because vigorous growth of all vegetative parameters in terms of plant height, leaves per plant as well as leaf length resulted in decrease the days taken to harvest of garlic in case of raised bed planting method as compared to flatbed method. The yield of garlic was significantly influenced by planting methods. The results showed that M_2 (Raised bed method) had the highest yield per plot and per hectare. M_1 (Flat method) produced the lowest yield per plot (14.40 kg) and per hectare (160.04 q). This could be attributed to favorable climatic conditions during the growth period, as well as increased biological activity and proper crop nutrition. The findings are comparable to those of Haque *et al.* 2002 [10] in garlic and Sarker *et al.* 2002 [40] in onion. The raised bed method produced significantly more cloves per bulb and maximum bulb diameter, bulb fresh weight, bulb dry weight than the flat bed method. This could be because, in most bulbous crops, bulbs are effectively developed in loose soil and better aeration and drainage and availability of adequate nutrients in bed sowing versus flat sowing. The findings were consistent with those of Pratap *et al.* (2017) [23], Kaur *et al.* (2017) [16], and Kondiram *et al.* (2015) [18]. The planting methods had a significant impact on bulb quality. The raised bed planting method produced the highest TSS, while the flat planting method produced the lowest TSS. This may be attributed to the raised bed planting method's favorable soil moisture conditions, which result in increased vegetative growth and higher photosynthetic activities, resulting in greater accumulation of food material and higher TSS content compared to flatbed planting method. These findings are consistent with the findings of Guljar *et al.* (2017) [9], Katyal and Chandha (1997) [15] and Kotgirwar *et al.* (1997) [19] in garlic. The effect of planting methods on dry matter content was found to be non-significant.

3.3 Interaction effect of planting methods and time

Interaction between various factors under study was found to be non- significant for most of the parameters was showed in Table 3. An interaction between planting methods and time revealed that maximum bulb fresh weight and TSS were obtained with the combination of raised bed planting method and early date of sowing *i.e* 10th September.

Table 1: Effect of planting time and planting methods on the growth and quality traits of garlic.

Treatments	Days to 50% mergence	Plant height (cm)	Number of leaves per plant	Leaf length (cm)	Tss (ºBrix)	Dry matter content (%)
Planting methods						
M_1 (Flatbed)	13.91	68.10	8.79	46.30	39.10	46.64
M_2 (Raised bed)	10.81	72.09	10.78	50.25	41.60	46.63
CD (p=0.05%)	1.65	2.55	1.56	3.67	0.698	N/S
Planting time						
D_1 (10th September)	10.25	72.51	12.92	52.51	43.49	48.95
D_2 (20thSeptember)	11.13	71.59	9.83	51.18	43.05	48.57
D_3 (1st October)	13.18	69.37	8.5	46.82	41.14	47.11
D_4 (11th October)	14.89	66.90	7.91	42.59	39.07	41.92
CD (p=0.05%)	2.34	3.60	2.21	5.19	0.987	N/S

Table 2: Effect of planting time and planting methods on the yield traits of garlic.

Treatments	Days taken to harvest	Bulb diameter (cm)	Number of cloves per bulb	Bulb fresh weight(g)	Bulb dry weight (g)	Bulb yield (kg/plot)	Bulb yield (q/ha)
Planting methods							
M_1 (Flatbed)	161.12	3.94	22.25	30.65	14.35	14.40	160.04
M_2 (Raised bed)	157.15	5.18	24.56	36.09	16.86	17.00	188.89
CD (p=0.05%)	3.99	1.05	2.03	1.48	1.57	1.80	5.91
Planting time							
D_1 (10th September)	152.66	5.70	26.59	39.07	19.08	17.73	197.00
D_2 (20th September)	156.38	4.68	25.24	34.75	16.87	15.99	177.68
D_3 (1st October)	162.12	4.34	22.12	30.63	14.32	15.21	169.00
D_4 (11th October)	165.38	3.51	19.67	29.01	12.15	13.88	154.17
CD (p=0.05%)	5.64	1.49	2.87	2.09	2.21	2.55	8.36

Table 3: Combined effect of planting time and planting methods on bulb fresh weight (g) and TSS (°Brix) of garlic

Characters Planting methods	Planting dates	Bulb fresh weight (g)	TSS (°Brix)
M_1- Flat bed	D_1-10 September	36.56	40.04
	D_2-20 September	32.98	38.42
	D_3-1 October	25.70	39.72
	D_4-11 October	27.34	38.22
M_2- Raised bed	D_1-10 September	41.59	43.26
	D_2-20 September	36.52	42.35
	D_3-1 October	30.68	40.89
	D_4-11 October	36.09	39.91
CD (A X B)		2.96	1.40

4. Conclusion

It can be concluded from the present investigation that the effect of planting methods and planting time on the performance of garlic (*Allium sativum* L.) under Punjab conditions was significant. Among the planting methods raised bed method with early date of sowing (10th, 20th September) proved to be most effective in increasing yield and quality attributes of garlic. Therefore, from the present investigation it was concluded that the raised bed method with an early sowing date was the most effective method for obtaining maximum yield and outstanding quality traits in garlic under Punjab conditions.

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