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Effect of Different Planting Dates and Spacing on Growth Parameters of Cabbage (*Brassica oleracea* var. *capitata* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To investigate the effect of various planting dates and spacing on cabbage growth.
Study Design: The experimental design Factorial Randomized Block Design (FRBD) was used.
Place and Duration of Study: An experiment was conducted in the rabi seasons of 2021–22 and 2022–23 at the Horticulture Research Farm, Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.)
Methodology: There were twelve treatments with three replications. The variety selected for experiment was Pusa Mukta.
Results: The combined data of two years showed that treatment P_1 (30 November) had significantly higher plant survivability (95.28%), plant height (14.67 cm, 21.31 cm and 28.39 cm) at 30, 45 and 60 DAT, respectively, stem diameter (2.11 cm), no. of non-wrapper leaves (16.28), no. of wrapper leaves (27.19), plant spread E-W (49.40 cm) and plant spread N-S (52.63 cm). Among spacings. The findings showed that the S_4 (60 cm x 60 cm) plant spacing achieved maximum plant survivability at 91.59%. It also led to the greatest plant height at 30, 45 and 60 days after transplanting (DAT) with measurements of 15.73 cm, 22.45 cm and 31.12 cm, respectively. Additionally, this spacing resulted in the largest stem diameter (2.31 cm), the highest no. of non-wrapper leaves (17.40), no. of wrapper leaves (28.30), greatest plant spread in both East-West (52.79 cm) and North-South (56.08 cm) directions.
Conclusion: The results obtained from pooled data of two years showed that treatment P_1 (30 November) and Spacing 60 cm x 60 cm had significantly higher growth parameters.

Keywords: Planting dates; plant spacing; cabbage; growth parameters.

1. INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) is among the most popular cole crops which is consumed globally, related to Brassicaceae (Cruciferae) family & has chromosome number 2n=2x=18. The "head," or edible part of the cabbage plant, is composed of many smooth, thick leaves that overlap one another. Cabbage varieties vary widely in terms of colour (from green to purple), leaf characteristics (from smooth to savoy), head form (from flat to pointed), and maturity (from early to late maturing). The most prevalent kinds are the green, round-headed ones (Splittstoesser, 1979, Phillips, 1993). All of these crops descended from the wild cabbage, which was originally from the Mediterranean region and gave rise to a wide range of cultivars, including *B. oleracea* vars. *capitata* and *botrytis* (Kochhar, 2010, Singh et al., 2001). India and other countries grow a lot of cabbage. It came to India during fifteenth century from Portugal (Singh et al., 2004). Crop yield is determined by a multitude of factors, two of the most critical ones being plant population and the ideal planting season. The current cropping pattern and the surrounding conditions determine the ideal planting timing. Cool temperatures are necessary for cabbage to grow to its full potential and form a head. The timing of planting is crucial, and meticulous seed sowing is required to ensure that the crop maximises the benefits of the prolonged chilled season. Plant morphology is altered in a variety of ways by competition brought through different spacing. In order to maximize the use of natural resources like nutrients, sunlight, soil moisture etc., as well as achieve a satisfactory yield and appropriate land use, it is important to maintain optimal plant spacing (Ullah et al., 2013). Crop spacing can vary based on climate, soil fertility and the suitability of different cultivars for a given area. Low plant density generally results in more robust plants with larger leaves, likely because there is less rivalry for nutrition, light and water in comparison to highest plant density (Bairwa et al., 2017) Although high population densities are often used for various crops to enhance vegetable production, closer spacing can provide benefits such as better soil protection, improved weed control, more efficient use of fertilizers and increased yields (Neto et al., 2016). The current study was conducted in light of the aforementioned information in order to determine the ideal planting time and plant spacing for improved cabbage growth.

2. MATERIALS AND METHODS

The research trial conducted at Horticulture Farm of Babasaheb Bhimrao Ambedkar University in Lucknow, Uttar Pradesh, India. The site is located at 80° 92' East longitude, 26° 76' North latitude, and 123 meters above MSL. The trial

took place during the rabi seasons of 2021-22 and 2022-23. The soil at the site was sandy loam with a slightly alkaline pH of 8.5, and comprised of 83.57 kg/ha of available Nitrogen, 14.40 kg/ha of available Phosphorus and 140.21 kg/ha of available Potash. The seedbed was one meter long and two meters wide, and the seeds used were of the Pusa Mukta cabbage variety. For transplanting, the seeds were evenly spaced at a distance of 5 cm, and they were seeded three times according to treatments on the seedbed in each year to preserve the same age. After sowing the seeds at 2 cm depth, they were lightly watered and covered with a fine layer of dirt. One month's old healthy young plants transferred on 30 November (P_1), 7 December (P_2) and 14 December (P_3) at four spacings *viz.* 45 cm x 30 cm (S_1), 45 cm x 45 cm (S_2), 60 cm x 45 cm (S_3) and 60 cm x 60 cm (S_4). The trial was conducted in Factorial RBD. There were twelve treatments with three replications. The Farm Yard Manure was mixed in the soil at the rate 20-25 tonne/ha fifteen days before transplantation. The recommended fertilizer dose of 180 kg N, 120 kg P and 100 kg K per hectare was applied using Urea, DAP & MOP respectively. As basal dose, half quantity of nitrogen and full quantity of phosphorous and potassium is applied to the soil. The remaining half quantity of nitrogen was divided in two equivalent amounts i.e., 1st top dressing applied at 30 DAT and 2nd at 45 DAT. All of the suggested practices like weeding and hoeing, irrigation, application of pesticides was implemented as per need throughout the duration of the cropping season. In each plot, five plants were chosen at random, and data was collected regarding the plants' survival, height (30, 45, and 60 DAT), stem diameter, number of wrapper and non-wrapper leaves, plant spread E-W and plant spread N-S at harvesting time. As indicated by Panse and Sukhatme (1985) the conventional technique was followed for statistical analysis (using OPSTAT software) of the growth parameter measurements from various sets of trials. After analysis, the data were shown at a significance level of 5 per cent.

3. RESULTS AND DISCUSSION

3.1 Effect of Planting Dates on Growth Parameters of Cabbage

3.1.1 Plant survivability

Planting dates had a major effect on the vegetative characters. The data on a pooled average basis (Table 1 and Fig. 1) showed that the planting date of 30 November (P1), had the significantly higher plant survival (95.28%), while the planting date of 14 December, (P3), had the lowest plant survival (84.81%). Early planting usually results in a longer growing season for the plant, which might enhance establishment and resilience. Plants benefit from positive weather conditions because they have more time to develop robust root systems before adverse ones appear. These results support Yasmin's (2008) findings in potatoes.

3.1.2 Plant height

It is revealed from Table 1 and Fig. 1 that the maximum plant height at 30 DAT (14.67 cm), 45 DAT (21.31 cm), and 60 DAT (28.39 cm) were reported under the planting date on 30 November (P_1). The minimum plant height at 30 DAT (13.34 cm), 45 DAT (18.17 cm), and 60 DAT (25.22 cm) were reported under planting date on 14 December (P_3). Temperature variations were the primary cause of changes in plant height, however favourable weather throughout growth period, may also have played a role. These findings validate observations of Saikia et al*.* (2010) and Kanase et al. [(2008) in broccoli, Yadav et al*.* (2021) in cabbage.

3.1.3 Stem diameter

The data on pooled mean basis revealed that stem diameter significantly influenced by planting time (Table 1 and Fig. 1). The maximum stem diameter (2.11 cm) was recorded from the plants which were transplanted on 30 November (P_1) while the minimum stem diameter (1.81 cm) recorded from the planting dates on 14 December (P_3). When comparing the vegetative development phase to an earlier planting date, the minimal diameter of the stem may be the result of decreased both night and day average temperatures. These findings concur with Abed et al*.* (2015) in cabbage, Singhal et al. (2009) and Kanase et al*.* (2018) in broccoli.

3.1.4 Number of non-wrapper leaves and wrapper leaves

It is revealed on the basis of pooled data of two years that number of non-wrappers leaves significantly influenced by distinct planting dates. The maximal number of non-wrapper leaves (16.28) was counted from the planting dates on 30th November (P_1) and the least number of non-wrapper leaves (13.94) were counted in plant that are planted on 14 December (P_3).

Table 1. Effect of planting dates on growth parameters of cabbage (Pooled data)

Planting Date	Plant survivability (%)	Plant height (cm)			Stem diameter (cm)	No. of non-wrapper leaves	No. of wrapper leaves	Plant Spread E-W	Plant Spread N-S
		30 DAT	45 DAT	60 DAT					
P_1	95.28	14.67	21.31	28.39	2.11	16.28	27.19	49.40	52.63
P_2	88.39	14.01	19.45	26.72	1.95	15.17	26.34	47.54	50.20
P_3	84.81	13.34	18.17	25.22	1.81	13.94	25.36	44.43	47.63
SEm (±)	1.81	0.18	0.23	0.24	0.02	0.13	0.19	0.32	0.44
C.D. (P=0.05)	3.66	0.37	0.47	0.49	0.04	0.27	0.38	0.65	0.89

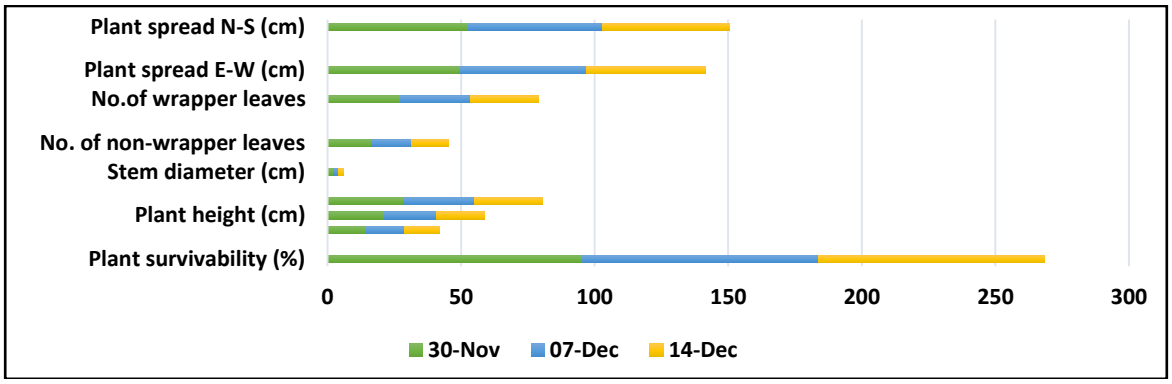

Fig. 1. Effect of planting dates on growth parameters

Number of wrapper leaves were significantly affected by various planting dates. The data according to average basis are shown in Table 1 and graphically illustrated in Fig. 1. The transplanting date of 30th November (P_1) performed better having maximum wrapper leaves (27.19) as compared to other dates while least number of wrapper leaves (25.36) were found under the planting date on 14th December (P_3). This is because the plants have optimum climatic conditions and a longer period to grow before unfavourable weather conditions impact their development. The outcomes are confined along with the studies of Ullah et al. (2013) in cabbage.

3.1.5 Plant Spread (East-West and North-South)

The timing of planting significantly impacts the canopy area of cabbage plants in both of north to south and east to west orientations. The results in Table 1 and Fig. 1 concluded that highest plant spread E-W (49.40 cm) recorded on planting date 30th November (P_1) while the lowest plant spread E-W (44.43 cm) were found under the planting date on 14th December (P_3). Plant spread N-S was significantly affected by various planting dates. The data according to average basis are shown in Table 1 and graphically illustrated in Figure. 1. Maximal plant spread N-S (52.63 cm) recorded under planting date of 30th November (P_1) while the lowest plant spread E-W (47.63 cm) were found under the planting date on 14th December (P_3). Typically, planting early results in more consistent growth. This could be resulted in more uniform east-west and north-south spread, as the plants have an extended growing period to develop and grow. These findings concur with Abed et al. (2015) in cabbage, Singhal et al. (2009) Thirupal et al. (2014) & Kanase et al. (2018) in broccoli.

3.2 Effect of Spacings on Growth Parameters of Cabbage

3.2.1 Plant survivability

Growth characters of cabbage were considerably impacted by various plant densities. The data on pooled mean basis (Table 2 and Fig. 2) revealed that the significantly higher plant survivability (91.59%) was observed under plant spacings at 60 cm x 60 cm (S_4) while minimum plant survivability (86.57%) found under spacing at 45 cm x 30 cm (S_1). The reason behind the plants' exceptional growth and survival may be traced back to the abundance of vital nutrients, water, light, and carbon dioxide in the 60 cm × 60 cm spacing. These findings concur with Muhammad et al. (2004) on onion investigation.

3.2.2 Plant height

The data on pooled mean basis (Table 2 and Fig. 2) revealed that the greatest plant height at 30 days after transplanting (15.73 cm), at 45 days after transplanting (22.45 cm), and at 60 days after transplanting (31.12 cm) was recorded under 60 cm x 60 cm (S_4) plant spacing. The least height at 30 DAT (11.31cm), at 45 DAT (16.07 cm) and at 60 DAT (21.66 cm) were reported under 45 cm x 30 cm (S_1) plant spacings. It demonstrated that as plant spacing increases, plant height also increased. This could be because plants are getting enough light and nourishment. The current experiment's trend was found to be consistent with Moniruzzaman (2011) Ullah et al. (2013) Singh et al. [(2007) and Yadav et al. (2021) in cabbage.

Table 2. Effect of spacing on growth parameters of cabbage (Pooled data)

Spacing	Plant survivability (%)	Plant height (cm)			Stem diameter (cm)	No. of non-wrapper leaves	No. of wrapper leaves	Plant spread E-W	Plant spread N-S
		30 DAT	45 DAT	60 DAT					
S_1	86.57	11.31	16.07	21.66	1.57	12.81	23.15	40.02	42.77
S_2	89.23	13.71	18.53	24.80	1.84	14.01	25.97	44.03	47.23
S_3	90.58	15.28	21.52	29.53	2.19	16.31	27.77	51.65	54.54
S_4	91.59	15.73	22.45	31.12	2.31	17.40	28.30	52.79	56.08
S.Em(±)	1.57	0.15	0.20	0.21	0.01	0.11	0.16	0.28	0.38
C.D. (P=0.05)	3.17	0.32	0.40	0.43	0.03	0.24	0.33	0.57	0.77

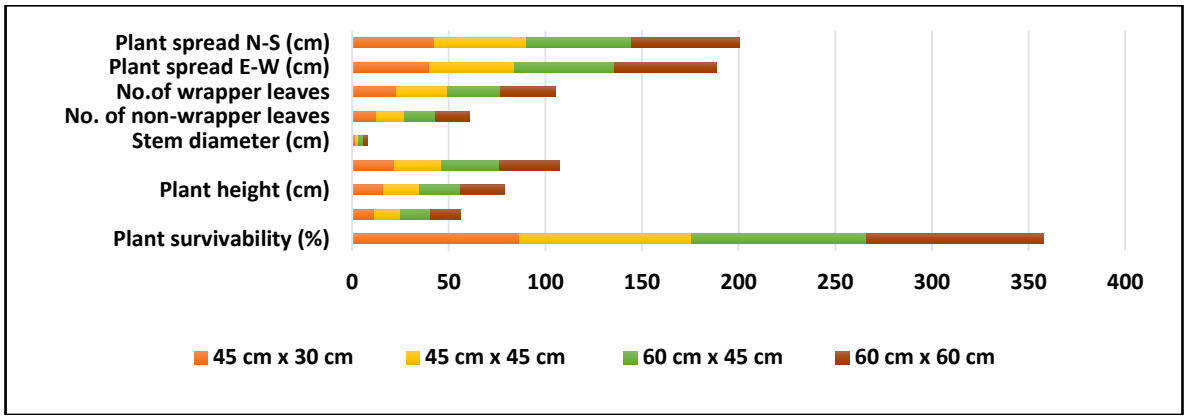

Fig. 2. Effect of spacing on growth parameters

3.2.3 Stem diameter

The data according to average basis disclosed that stem diameter significantly influenced by planting time (Table 1 and Fig. 1). The maximum stem diameter (2.31 cm) observed in those plants which were transplanted at 60 cm x 60 cm (S_4). while the minimum stem diameter (1.57 cm) measured in those plants which were transplanted at 45 cm x 30 cm (S_1) spacing. This could be because they received an adequate amount of light and nutrients. Similar findings are closely aligned with results of Abed et al. (2015) and Yadav et al. (2021) in cabbage.

3.2.4 Number of non-wrapper leaves and wrapper leaves

It is revealed from the pooled data (Table 2 and Fig. 2) of both years that number of non-wrapper leaf greatly impacted by various plant configurations. As plant spacing enhanced, so did the number of non-wrapper leaves. The maximal number of non-wrapper leaves (17.40) were counted from the plot which have less plant densities (60 cm x 60 cm) and the least no. of non-wrapper leaves (12.81) were obtained from plants which were transplanted at 45 cm x 30 cm (S_1) plant spacing.

Different plant spacing had a substantial impact on the number of wrapper leaves. The pooled mean basis data presented in Table 2, while Fig. 2 provides a visual representation of the same. In comparison with other spacings, the plant spacing of 60 cm x 60 cm (S_4) performed better, yielding the largest number of wrapper leaves (28.30). Conversely, the plants transplanted at 45 cm × 30 cm (S_1) plant spacing had the lowest number of wrapper leaves (23.15). More light, moisture and nutrients were available to plants transplanted wider apart than to those grown at closer spacing, which probably the cause of the latter group's plants performed better during growth. The current experiment's tendency was found to be consistent with Moniruzzaman's (2011) findings in cabbage.

3.2.5 Plant spread (East-West and North-South)

The data on pooled mean basis (Table 2 and Fig. 2) revealed that highest plant spread E-W (52.79 cm) recorded from the plant which were planted at 60 cm x 60 cm (S_4) whereas minimum plant spread E-W (40.02 cm) were found from the plots in which plants are transplanted at 45 cm x 30 cm (S_1) plant spacing.

Plant spread N-S was significantly affected by various plant densities. The data on pooled mean basis are shown in Table 2 and graphically illustrated in Fig. 2. The maximal plant spread N-S (56.08 cm) was recorded under plant spacing at 60 cm x 60 cm (S_4) whereas least plant spread E-W (42.77 cm) were found from the plants which were transplanted at 45 cm x 30 cm (S_1) plant spacing. Higher spacings typically enable cabbage plants to grow larger and spread more in both directions. With more space, plants can develop a more even and balanced spread. The decreased competition for resources fosters healthier growth and a greater overall spread. The patterns of current findings confirmed with the results of Sandhu et al. (1999) in cabbage, Thirupal et al. (2014) in broccoli (1998).

4. CONCLUSION

The findings of these experiment concluded that the planting time and spacing showed significant impact on the different parameters observed.

Generally, the early planting date (30th November) performed better among different dates of planting while wider plant spacing 60 cm x 60 cm gave outstanding results on growth parameters of cabbage.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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