

Original Research Article

Effect of Different Spacing and Time of Planting on growth and yield of Chinese Cabbage (*Brassica rapa*) Under Prayagraj Agro Climatic Condition

ABSTRACT

A field experiment was conducted during the rabi season in 2022-23 at vegetable research farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj (UP). The experiment consisted of nine treatments combinations with three plants spacing viz. (i) 30 x 45cm, (ii) 45 x 60cm and (iii) 45 x 45cm and three levels of sowing date viz. (i) November 5th 2022, (ii) November 12th 2022, (iii) November 19th 2022, were included in the study in Randomized Block Design with three replications. The growth, yield and quality contributing all characters were significantly influenced by the treatments. The highest plant height, number of leaves, weight of head per plant, chlorophyll content and length of outer leaves (cm) as recorded in T₆ (D²S³) (plants sowing November 12th 2022 with spacing 45 x 45cm) followed by T₃ (D¹S³) and lowest in T₇ (D³S¹). The maximum weight of head per m², yield per plot (79.6kg) and yield per hectare (89.1t ha) were recorded ⁻¹ in T₄ (D²S¹) (plants sowing November 12th 2022 with spacing 30 x 45cm) followed by T₁ (D¹S¹) and minimum weight of head per m², yield per plot (35.6kg) and yield per hectare (199.0 t ha⁻¹) were recorded in T₈ (D³S²) of Chinese cabbage.

Key words: Chinese Cabbage, spacing, sowing, growth, and yield

Introduction

Chinese cabbage (*Brassica pekinensis* and *B. chinensis*, 2n = 20) is annually grown as a salad crop. It is indigenous to China and eastern Asia, where it has been in cultivation since the fifth century. Two more or less distinct species of Chinese cabbage are grown. One of these species is Pe-tsai—*Brassica campestris* subsp. *pekinensis* (*B. pekinensis*). This resembles Cos lettuce but produces a much larger head that is elongated and compact. The other species is Pak-choi—*Brassica campestris* subsp. *chinensis* (*B. chinensis*). This resembles Swiss chard in growth habit. The leaves are long, dark-green, and oblong or oval, and they do not form a solid head. It is also called Chinese mustard. This chapter provides an overview of the cytology and genetics of Chinese cabbage. Chinese cabbage contains 2n = 20 chromosomes. *Brassica pekinensis* contains two nucleolus organizing chromosomes per haploid set.

One of the significant determinants in cabbage production practices is the planting date and plant spacing. The selection of an appropriate planting date and an appropriate plant spacing has an impact on the yield-contributing characteristics, and ultimately on the total production. Moreover, the attributes that affect head quality are the most significant. Previous studies have revealed the impact of planting date on cabbage vegetative characteristics, yield, and head attributes, (Singh *et al.*, 2010; Thirupal *et al.*, 2014 Jayamanne *et al.*, 2015). The maturity and timing of harvesting of cabbage plants are directly related to the date of planting. Temperature, day period, and light intensity are connected to it. The ideal planting time determines the ideal climatic and environmental conditions for producing cabbage. The total and marketable yield of cabbage is also impacted by the planting date, (Wszelaki and Kleinhenz, 2003, Tendaj *et al.*, 2012). They claimed that earlier planting dates resulted in the highest yield, but later planting dates resulted in a much lower total and marketable output. Moreover, head and core features are impacted by planting date, (Greenland *et al.*, 2000; Orzolek *et al.*, 2000; Kleinhenz and Wszelaki, 2003, Khan *et al.*, 2015).

Materials and Methods

The experiment was conducted during *Rabi* season of 2022 at vegetable research farm of Department of Horticulture, Naini Agricultural Institute, SHUATS Allahabad. The experimental site is located in the sub-tropical region with 25°28'46.14" N latitude 81°54'49.95" E longitudes and 98 meter above sea level altitudes. The soil was having a texture of sandy loam soil with pH 7.2. Seeds of Palampur green variety of cabbage were used in the experiment. Seed bed was made on 5th November 2022 for raising cabbage seedlings. The size of the seed bed was 2m×2m. Then the seeds were sown on seed bed at three times on 5th November 2022, 12th November 2022, and 19th November 2022 to maintain the same age at the time of transplanting and sowing was done thinly spaced at 5 cm distance and the seeds were sown at a depth of 2 cm and covered with a fine layer of soil followed by light watering with a water can. Healthy seedlings were transplanted. The experiment was conducted in Randomized Block Design (RBD) with three replications. Three different plants spacing *viz.*, S1 (30 cm×45 cm), S2 (45 cm×60 cm) and S3 (45 cm×45 cm) and three different sowing times *viz.*, D1: 5th November 2022, D2: 12th November 2022 and D3: 19th November 2022 were maintained in this study. Intercultural operations were done as and when needed. The head cabbage was harvested during the period from 5th January, 12th January, to 19th January 2023. Data on plant height, number of leaves per plant, chlorophyll content, weight of head per plant, head yield per square meter, length of outer leaves, yield per plot (kg) and yield per hectare contributing were recorded from five randomly selected plants. The recorded data on different parameters were statistically analyzed with the Analysis of Variance⁷ (Fischer, 1960) in MS -Excel at 5% level of significance for interpretation of the result.

Table 1. Treatments and their combination with symbol.

S. No.	Treatment	Treatment combination	Symbol
1	T ₁	(30 x 45cm) S ¹ 1 st week	D ¹ S ¹
2	T ₂	(45 x 60 cm) S ² 1 st week	D ¹ S ²
3	T ₃	(45 x 45 cm) S ³ 1 st week	D ¹ S ³
4	T ₄	(30 x 45 cm) S ¹ 2 nd week	D ² S ¹
5	T ₅	(45 x 60 cm) S ² 2 nd week	D ² S ²
6	T ₆	(45 x 45 cm) S ³ 2 nd week	D ² S ³
7	T ₇	(30 x 45 cm) S ¹ 3 rd week	D ³ S ¹
8	T ₈	(45 x 60 cm) S ² 3 rd week	D ³ S ²
9	T ₉	(45 x 45 cm) S ³ 3 rd week	D ³ S ³

The source of NPK and Molybdenum as Urea, SSP, MOP and Sodium molybdate (Na₂MoO₄.2H₂O) respectively.

Results and Discussion

3. Results and Discussion

3.1. Plant height (cm)

Plant height (cm) at 30 DAS and 60 DAS was significantly influenced by different spacings with and time of planting (Table 2). It is evident from the data that the highest plant height (cm) at 30 DAS of Chinese cabbage was recorded in the treatment T₆ (D²S³) (25.87cm) followed by T₃ (D¹S³) (22.81cm) and lowest in the case of T₇ (D³S¹) (17.94 cm). The plant height (cm) at 60 DAS was recorded significantly higher with treatment T₆ (D²S³) (36.21cm) followed by T₃ (D¹S³) (31.47cm), T₄ (D²S¹) (30.91cm), T₅ (D²S²) (29.83cm), T₁ (D¹S¹) (29.69cm), (D¹S²) (28.92cm), T₉ (D³S³) (27.36cm), T₈ (D³S²) (26.26cm) and lowest in treatment T₇ (D³S¹) (25.12cm). Increased plant density coupled with shallow root system limits the availability of space for lateral growth. This leads to the competition between the plants for light and nutrients, resulting in increased plant height. These findings were in agreement with

Rastogi *et al.*, (1987) in radish, Khurana *et al.*, (1990) in cauliflower and Hill (2000) in Chinese cabbage.

3.2. Number of leaves plant⁻¹

Number of leaves plant⁻¹ at 30 DAS and 60 DAS was significantly influenced by different spacings with and time of planting (Table 2). The number of leaves plant⁻¹ at 30 DAS of Chinese cabbage was not influenced significantly by different spacings with and time of planting of different treatments. The highest number of leaves plant⁻¹ at 30 DAS of Chinese cabbage was recorded in the treatment T₆ (D²S³) (13.39) followed by T₃ (D¹S³) (13.16) and the lowest no. of leaves in case of T₇ (D³S¹) (10.70). At 60 DAS, number of leaves plant⁻¹ was recorded significantly higher with treatment T₆ (D²S³) (20.69) followed by T₃ (D¹S³) (20.30), T₄ (D²S¹) (19.16), T₁ (D¹S¹) (16.94), T₂ (D¹S²) (16.21), T₅ (D²S²) (18.74), T₉ (D³S³) (10.93), T₈ (D³S²) (10.89) and lowest leaves in treatment T₇ (D³S¹) (10.70). The treatment T₆ (D²S³) was found significantly superior to all treatments but was at par with T₃ (D¹S³). This might be due to lesser competition for nutrients and light amongst the plants with lower plant density. Hence in wider spacing due to the availability of more space and light, the crop might have produced a greater number of leaves per plant. These results were in conformity with the results of Hill (2000) in Chinese cabbage, Singh (2005) in cauliflower and Agarkar *et al.*, (2010) in broccoli. The wider spacing with early sowing produced heavier number of leaves than closer spacing with early sowing reported by in Broccoli by Suthar *et al.*, 2017.

3.3. Length of outer leaves

Length of outer leaves (cm) showed statistically significant differences due to the different spacings with and time of planting (Table 2). The maximum length of outer leaves (cm) was recorded with treatment T₆ (D²S³) (5.57cm) closely followed by T₃ (D¹S³) (5.54cm) and the minimum length of outer leaves (cm) was recorded in treatment T₇ (D³S¹) (4.45cm). The growth attributes of plant are maximum might be due to fact that the plant under in favorable climate and the late sowing of seedling was not congenial for normal growth of plant reported by Gonzalez, 1980, Gautam *et al.*, 1998, Bobade, 2001.

3.4. Weight of head (kg) per plant

Weight of the head (kg) per plant showed statistically significant variation due to the different spacings and times of planting (Table 3). Treatment T₆ (D²S³) was found significantly superior to all treatments but was at par with T₃ (D¹S³) and T₄ (D²S¹). The weight of the head (kg) per plant was recorded as significantly higher with treatment T₆ (D²S³) (2.75kg) followed by T₃ (D¹S³) (2.72 kg), T₄ (D²S¹) (2.69 kg), T₅ (D²S²) (2.65 kg), T₁ (D¹S¹) (2.56 kg), T₂ (D¹S²) (2.53 kg), T₉ (D³S³) (2.46 kg), T₈ (D³S²) (2.41 kg) and lowest in treatment T₇ (D³S¹) (2.37 kg). Fresh weight of head was maximum under 01 October sowing and 45 x 45cm spacing recorded at 14.72 cm, 16.80 cm and 204.50 gm in Broccoli by Suthar *et al.*, 2017. The wider spacing produced heavier head than closer spacing. Similar results were reported by Sharma *et al.*, (1995) in broccoli, Sharma and Koul (2004) in leek and Chatterjee (2006) in cauliflower.

3.5. Weight of head per m²

Due to different spacings and times of planting along with the weight of head per m² of Chinese cabbage varied insignificantly (Table 3). T₄ (D²S¹) was shown to have a significantly higher weight of head per m² than all other treatments. The highest weight of head per m² was recorded with treatment T₄ (D²S¹) (19.90kg) followed by T₁ (D¹S¹), T₇ (D³S¹), T₆ (D²S³), T₃ (D¹S³), T₉ (D³S³), T₅ (D²S²), T₂ (D¹S²) and lowest in treatment T₈ (D³S²) (8.91). The maximum yield per plot was found superior at higher plant density which was possibly due to a greater number of plants per unit area; higher ground covers of leaf area resulted in higher light

interception and hence, higher assimilate production. Similar results have been reported by Sharma and Chaudhary (1996) in cauliflower and Agarwal *et al.*, (2007) in broccoli.

3.6. Chlorophyll content

Chlorophyll content (mg g^{-1}) showed statistically significant differences due to the different spacings with and time of planting (Table 2). The maximum chlorophyll content was recorded with treatment T_6 (D^2S^3) (0.57mg g^{-1}) closely followed by T_3 (D^1S^3) and lowest in treatment T_7 (D^3S^1) (0.47mg g^{-1}). These quality attributes concentration significantly decreased with every delay in the planting date and they were affected by closer plant spacing and some condition effect might to be due to wider spacing plant get more better light, better availability of space, aeration and soil moisture as well as better nutrient for the growth reported by Suthar *et al.*, 2017.

3.7. Yield per plot (kg)

Yield per plot (kg) showed statistically significant differences due to the different spacings with and time of planting (Table 3). T_4 (D^2S^1) was shown to have a significantly higher yield per plot (kg) than all other treatments. The highest yield per plot (kg) was recorded with treatment T_4 (D^2S^1) (79.6kg) followed by T_1 (D^1S^1) (75.8kg), T_7 (D^3S^1) (70.2kg), T_6 (D^2S^3) (54.5kg), T_3 (D^1S^3) (53.9kg), T_9 (D^3S^3) (48.7kg), T_5 (D^2S^2) (39.3kg), T_2 (D^1S^2) (37.4kg) and lowest in treatment T_8 (D^3S^2) (35.6kg). Maximum yield per plot and hectare obtained in closer spacing this might be due to fact that the significant increases in number of marketable heads with increasing plant density. There were more plants per unit area, which may have contributed to the greater maximum yield per plot. More ground coverings of leaf area also led in higher light absorption and, thus, higher assimilate production. Both Sharma and Chaudhary (1996) for cauliflower and Agarwal *et al.* (2007) for broccoli reported similar outcomes.

3.8. Yield per hectare (t ha^{-1})

Yield per hectare (t ha^{-1}) showed statistically significant differences due to the different spacings with and time of planting (Table 3). The yield per hectare (t ha^{-1}) in T_4 (D^2S^1) was found significantly superior to all treatments. The highest yield per hectare (t ha^{-1}) was recorded with treatment T_4 (D^2S^1) (199.0 t ha^{-1}) followed by T_1 (D^1S^1) (189.4 t ha^{-1}), T_7 (D^3S^1) (175.6 t ha^{-1}), T_6 (D^2S^3) (136.2 t ha^{-1}), T_3 (D^1S^3) (134.7 t ha^{-1}), T_9 (D^3S^3) (121.7 t ha^{-1}), T_5 (D^2S^2) (98.3 t ha^{-1}), T_2 (D^1S^2) (93.5 t ha^{-1}) and lowest yield per hectare (t ha^{-1}) was recorded in treatment T_8 (D^3S^2) (89.1 t ha^{-1}). This is due to the reality that as plant spacing decreases, total plant population increases and this in turn contributes to increase in total head yield. The current result is in agreement with works of different authors. Hossain *et al.*, (2011) recorded that closer spacing (60 x 40 cm) produced the maximum yield (18.8 t/ha), which was statistically similar when spaced at 60 x 50 cm (17.6 t/ha) and lowest yield (16 t/ha) was from wider (60 x 60 cm) spacing in broccoli. "Captain" broccoli hybrid recorded the highest yield (10.8 t/ha) at highest plant density (60 x 50 cm) due to a greater number of plants/m², whereas at 70 x 50 cm spacing higher values of curd weight and morphometric traits were recorded (Fabek *et al.*, 2011). According to Bhangre *et al.*, (2011) planting of broccoli at a spacing of 45 x 30 cm and 60 x 60 cm recorded higher (77.08 q/ha) and lower head yield (50.38 q/ha), respectively. Similar results have been reported by Agarwal *et al.*, (2007) in broccoli.

4. Conclusion

The experimental result revealed that T_4 (D^2S^1) combination of planting time 12th November and wider spacing 45cm x 45cm exhibited better results in terms of growth and yield parameters studied. The findings of the experiment indicated that the yield of cabbage head was greatly affected by this planting time and spacing.

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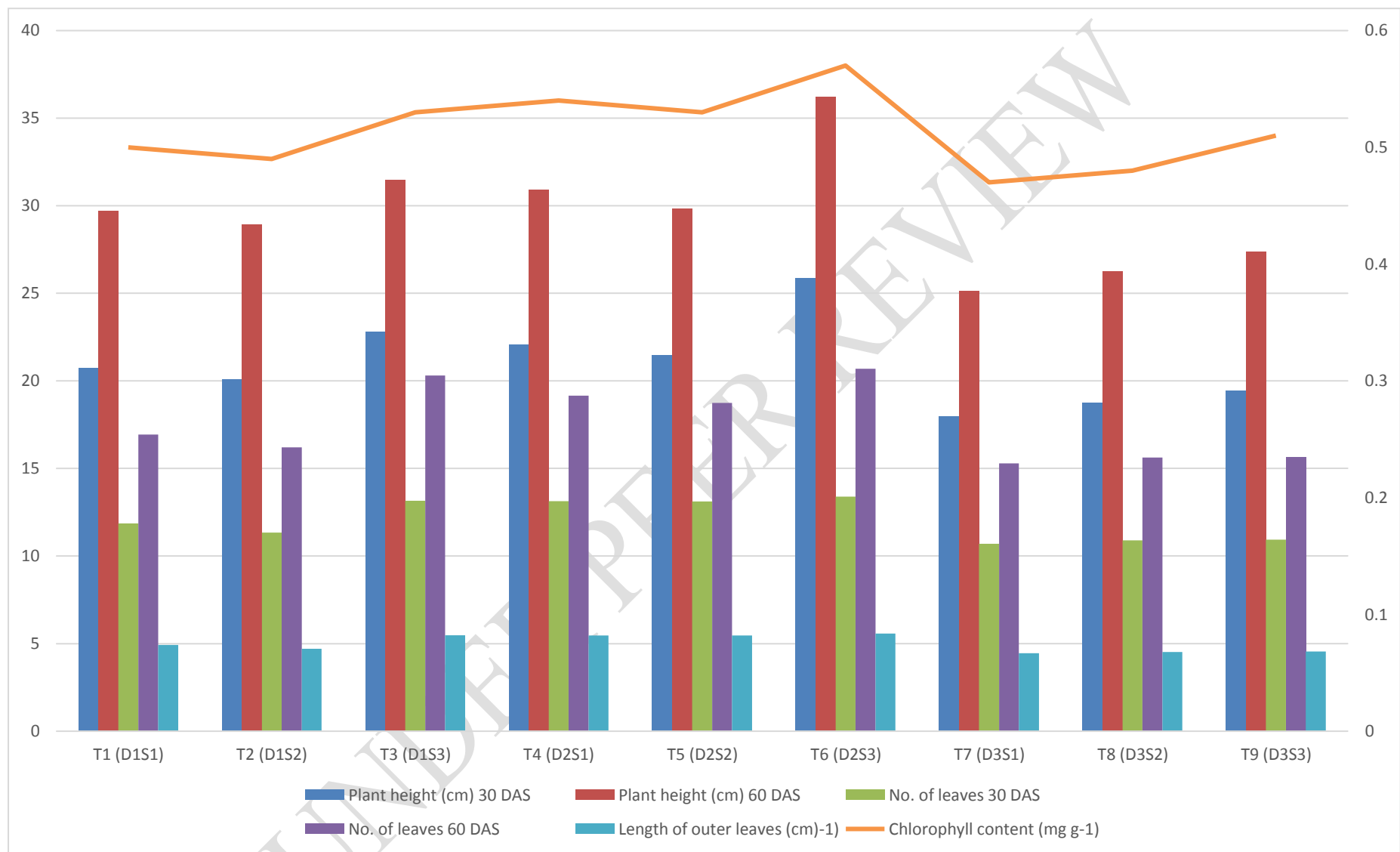
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Table:2 Effect of different spacings with and time of planting on growth parameters of Chinese cabbage

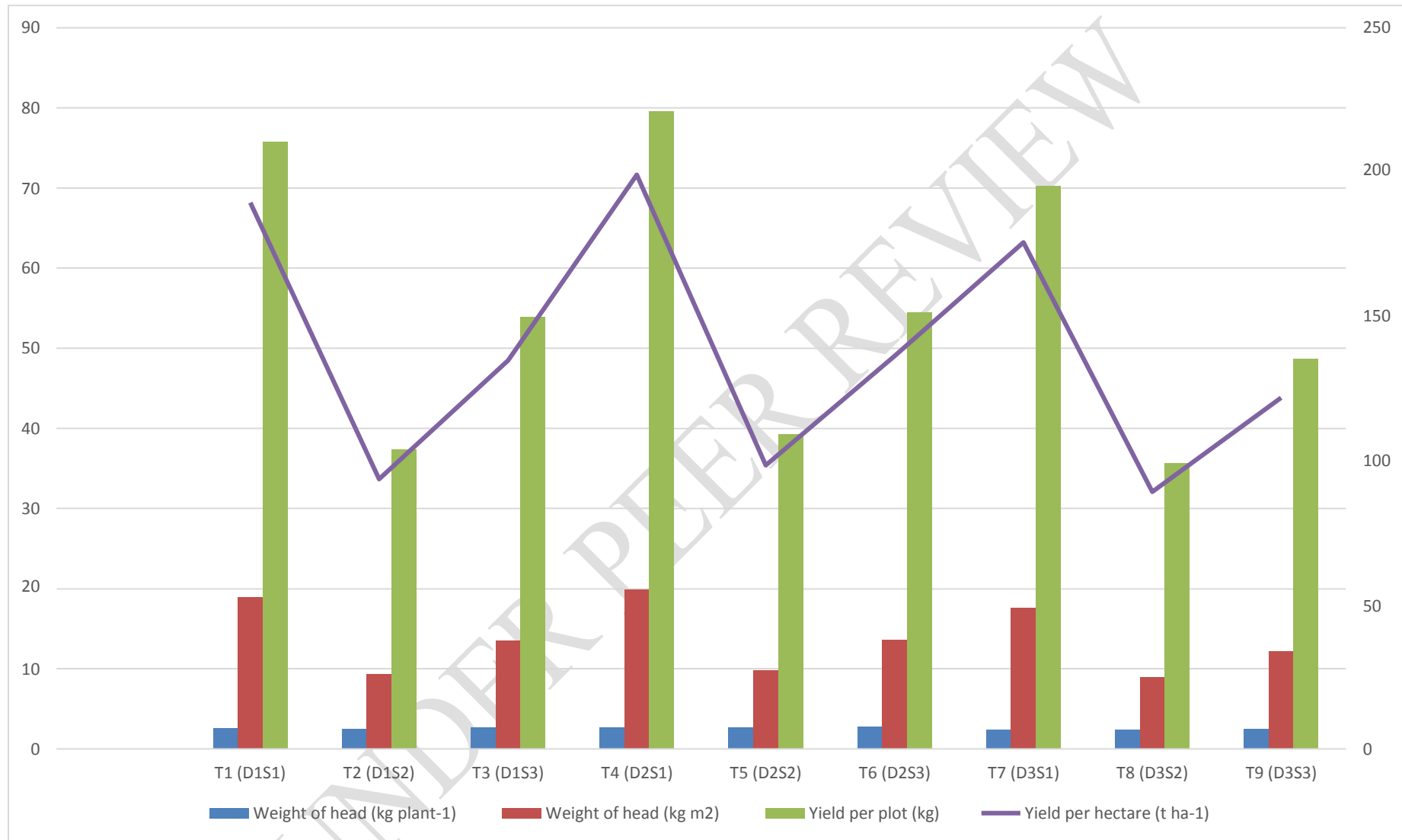
Treatment	Plant height (cm)		No. of leaves		Chlorophyll content (mg g ⁻¹)	Length of outer leaves (cm) ⁻¹
	30 DAS	60 DAS	30 DAS	60 DAS		
T ₁ (D ¹ S ¹)	20.71	29.69	11.85	16.94	0.50	4.93
T ₂ (D ¹ S ²)	20.06	28.92	11.33	16.21	0.49	4.71
T ₃ (D ¹ S ³)	22.81	31.47	13.16	20.30	0.53	5.48
T ₄ (D ² S ¹)	22.08	30.91	13.13	19.16	0.54	5.47
T ₅ (D ² S ²)	21.46	29.83	13.11	18.74	0.53	5.46
T ₆ (D ² S ³)	25.87	36.21	13.39	20.69	0.57	5.57
T ₇ (D ³ S ¹)	17.94	25.12	10.70	15.30	0.47	4.45
T ₈ (D ³ S ²)	18.76	26.26	10.89	15.63	0.48	4.53
T ₉ (D ³ S ³)	19.44	27.36	10.93	15.66	0.51	4.55
F-test	NS	S	NS	S	NS	NS
S.Ed. (±)	1.55	0.59	0.75	0.35	0.025	0.44
C.D. (at 5%)	4.65	1.76	2.24	1.05	0.074	1.33



Graph 1: Effect of different spacings with and time of planting on growth parameters of Chinese cabbage

Table:3 Effect of different spacings with and time of planting on yield parameters of Chinese cabbage

Treatment	Weight of head (kg plant⁻¹)	Weight of head (kg m²)	Yield per plot (kg)	Yield per hectare (t ha⁻¹)
T ₁ (D ¹ S ¹)	2.56	18.94	75.8	189.4
T ₂ (D ¹ S ²)	2.53	9.35	37.4	93.5
T ₃ (D ¹ S ³)	2.72	13.47	53.9	134.7
T ₄ (D ² S ¹)	2.69	19.90	79.6	199.0
T ₅ (D ² S ²)	2.65	9.83	39.3	98.3
T ₆ (D ² S ³)	2.75	13.62	54.5	136.2
T ₇ (D ³ S ¹)	2.37	17.56	70.2	175.6
T ₈ (D ³ S ²)	2.41	8.91	35.6	89.1
T ₉ (D ³ S ³)	2.46	12.17	48.7	121.7
F-test	S	S	S	S
S.Ed. (±)	0.03	0.20	0.80	2.00
C.D. (at 5%)	0.09	0.60	2.40	6.00



Graph 2: Effect of different spacings with and time of planting on yield parameters of Chinese cabbage

UNDER PEER REVIEW