International Journal of Environment and Climate Change

Volume 13, Issue 10, Page 1844-1852, 2023; Article no.IJECC.105208
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Different Spacing and Time of Planting on Growth and Yield of Chinese Cabbage (*Brassica rapa*) under Prayagraj Agro Climatic Condition

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Authors' contributions

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

Article Information

DOI: 10.9734/IJECC/2023/v13i102841

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/105208

Original Research Article

Received: 16/06/2023
Accepted: 22/08/2023
Published: 01/09/2023

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

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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 T_6 (D^2S^3) (plants sowing November 12th 2022 with spacing 45 x 45cm) followed by T_3 (D^1S^3) and lowest in T_7 (D^3S^1). The maximum weight of head per m^2, yield per plot (79.6kg) and yield per hectare (89.1t ha) were recorded $^{-1}$ in T_4 (D^2S^1) (plants sowing November 12th 2022 with spacing 30 x 45cm) followed by T_1 (D^1S^1) and minimum weight of head per m^2, yield per plot (35.6kg) and yield per hectare (199.0 t ha^{-1}) were recorded in T_8 (D^3S^2) of Chinese cabbage.

Keywords: Chinese cabbage; spacing; sowing; growth; yield.

1. 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" [1-3]. "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" [4,5]. 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, [6,7,4,8]. Keeping these facts in view, this study evaluated effect of different spacing and time of planting on growth and yield of Chinese cabbage under under field condition in local agro climatic condition.

2. 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 $25^0$28'46.14" N latitude 81^0 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

Table 1. Treatments and their combination with symbol

S. No.	Treatment	Treatment combination	Symbol
1	T_1	(30 x 45cm) S^1 1st week	D^1S^1
2	T_2	(45 x 60 cm) S^2 1st week	D^1S^2
3	T_3	(45 x 45 cm) S^3 1st week	D^1S^3
4	T_4	(30 x 45 cm) S^1 2nd week	D^2S^1
5	T_5	(45 x 60 cm) S^2 2nd week	D^2S^2
6	T_6	(45 x 45 cm) S^3 2nd week	D^2S^3
7	T_7	(30 x 45 cm) S^1 3rd week	D^3S^1
8	T_8	(45 x 60 cm) S^2 3rd week	D^3S^2
9	T_9	(45 x 45 cm) S^3 3rd week	D^3S^3

The source of NPK and Molybdenum as Urea, SSP, MOP and Sodium molybdate ($Na_2MoO_4.2H_2O$) respectively

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 Variance' [9] in MS -Excel at 5% level of significance for interpretation of the result.

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 1). It is evident from the data that the highest plant height (cm) at 30 DAS of Chinese cabbage was recorded in the treatment T_6 (D^2S^3) (25.87cm) followed by T_3 (D^1S^3) (22.81cm) and lowest in the case of T_7 (D^3S^1) (17.94 cm). The plant height (cm) at 60 DAS was recorded significantly higher with treatment T_6 (D^2S^3) (36.21cm) followed by T_3 (D^1S^3) (31.47cm), T_4 (D^2S^1) (30.91cm), T_5 (D^2S^2) (29.83cm), T_1 (D^1S^1) (29.69cm), (D^1S^2) (28.92cm), T_9 (D^3S^3) (27.36cm), T_8 (D^3S^2) (26.26cm) and lowest in treatment T_7 (D^3S^1) (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*.,* [10] in radish, Khurana et al*.,*[11] in cauliflower and Hill [12] 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 1). 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 T_6 (D^2S^3) (13.39) followed by T_3 (D^1S^3) (13.16) and the lowest no. of leaves in case of T_7 (D^3S^1) (10.70). At 60 DAS, number of leaves plant^{-1} was recorded significantly higher with treatment T_6 (D^2S^3) (20.69) followed by T_3 (D^1S^3) (20.30), T_4 (D^2S^1) (19.16), T_1 (D^1S^1) (16.94), T_2 (D^1S^2) (16.21), T_5 (D^2S^2) (18.74), T_9 (D^3S^3) (10.93), T_8 (D^3S^2) (10.89) and lowest leaves in treatment T_7 (D^3S^1) (10.70). The treatment T_6 (D^2S^3) was found significantly superior to all treatments but was at par with T_3 (D^1S^3). 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 [12] in Chinese cabbage, Singh [13] in cauliflower and Agarkar et al*.,* [14] 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*.,* [15].

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 1). The maximum length of outer leaves (cm) was recorded with treatment T_6 (D^2S^3) (5.57cm) closely followed by T_3 (D^1S^3) (5.54cm) and the minimum length of outer leaves (cm) was recorded in treatment T_7 (D^3S^1) (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, [16], Gautam et al*.,* [17], Bobade, [18].

3.4 Weight of head (kg) per plant

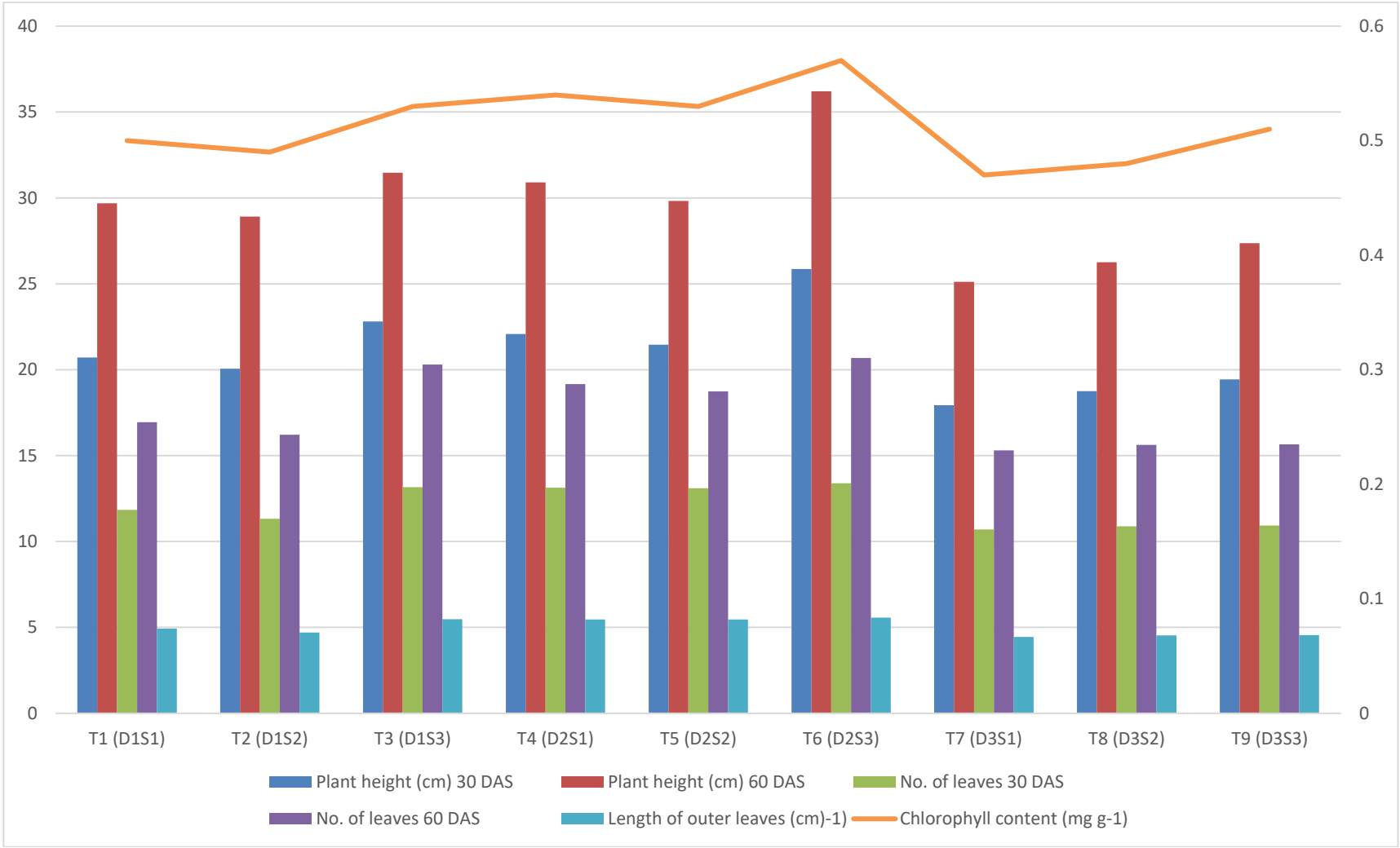
Weight of the head (kg) per plant showed statistically significant variation due to the different spacings and times of planting (Table 2). Treatment T_6 (D^2S^3) was found significantly

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

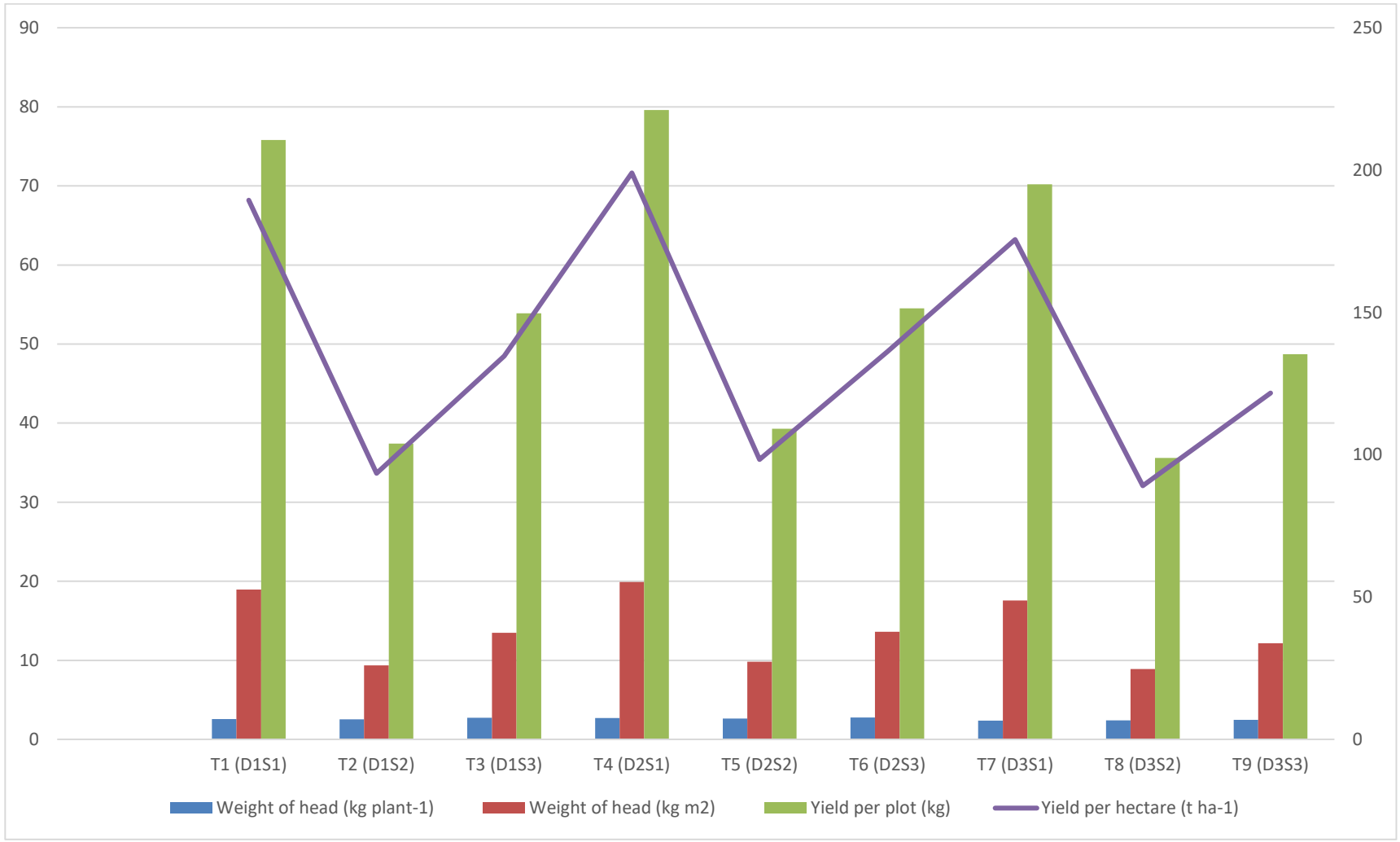
Treatment	Plant height (cm)		No. of leaves		Chlorophyll content (mg g^{-1})	Length of outer leaves $(cm)^{-1}$)
	30 DAS	60 DAS	30 DAS	60 DAS		
T_1 (D^1S^1)	20.71	29.69	11.85	16.94	0.50	4.93
T_2 (D^1S^2)	20.06	28.92	11.33	16.21	0.49	4.71
T_3 (D^1S^3)	22.81	31.47	13.16	20.30	0.53	5.48
T_4 (D^2S^1)	22.08	30.91	13.13	19.16	0.54	5.47
T_5 (D^2S^2)	21.46	29.83	13.11	18.74	0.53	5.46
T_6 (D^2S^3)	25.87	36.21	13.39	20.69	0.57	5.57
T_7 (D^3S^1)	17.94	25.12	10.70	15.30	0.47	4.45
T_8 (D^3S^2)	18.76	26.26	10.89	15.63	0.48	4.53
T_9 (D^3S^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

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 m^2)	Yield per plot (kg)	Yield per hectare (t ha^{-1})
T_1 (D^1S^1)	2.56	18.94	75.8	189.4
T_2 (D^1S^2)	2.53	9.35	37.4	93.5
T_3 (D^1S^3)	2.72	13.47	53.9	134.7
T_4 (D^2S^1)	2.69	19.90	79.6	199.0
T_5 (D^2S^2)	2.65	9.83	39.3	98.3
T_6 (D^2S^3)	2.75	13.62	54.5	136.2
T_7 (D^3S^1)	2.37	17.56	70.2	175.6
T_8 (D^3S^2)	2.41	8.91	35.6	89.1
T_9 (D^3S^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 1. Effect of different spacings with and time of planting on growth parameters of Chinese cabbage



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

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 T_6 (D^2S^3) (2.75kg) followed by T_3 (D^1S^3) (2.72 kg), T_4 (D^2S^1) (2.69 kg), T_5 (D^2S^2) (2.65 kg), T_1 (D^1S^1) (2.56 kg), T_2 (D^1S^2) (2.53 kg), T_9 (D^3S^3) (2.46 kg), T_8 (D^3S^2) (2.41 kg) and lowest in treatment T_7 (D^3S^1) (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*.,* [15]. The wider spacing produced heavier head than closer spacing. Similar results were reported by Sharma et al*.,* [19] in broccoli, Sharma and Koul [20] in leek and Chatterjee [21] in cauliflower.

3.5 Weight of Head per m^2

Due to different spacings and times of planting along with the weight of head per m^2 of Chinese cabbage varied insignificantly (Table 2). T_4 (D^2S^1) was shown to have a significantly higher weight of head per m^2 than all other treatments. The highest weight of head per m^2 was recorded with treatment T_4 (D^2S^1) (19.90kg) followed by T_1 (D^1S^1), T_7 (D^3S^1), T_6 (D^2S^3), T_3 (D^1S^3), T_9 (D^3S^3), T_5 (D^2S^2), T_2 (D^1S^2) and lowest in treatment T_8 (D^3S^2) (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 [22] in cauliflower and Agarwal et al*.,* [23] 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 1). 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) (0.47 mg 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” Suthar et al*.,* [15].

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 2). 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 [20] for cauliflower and Agarwal et al*.* [23] 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 2). 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) (189.4t ha^{-1}), T_7 (D^3S^1) (175.6t ha^{-1}), T_6 (D^2S^3) (136.2t ha^{-1}), T_3 (D^1S^3) (134.7t ha^{-1}), T_9 (D^3S^3) (121.7t ha^{-1}), T_5 (D^2S^2) (98.3t ha^{-1}), T_2 (D^1S^2) (93.5t ha^{-1}) and lowest yield per hectare (t ha^{-1}) was recorded in treatment T_8 (D^3S^2) (89.1t 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*.,* [24] 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” [25]. According to Bhangre et al*.,* [26] “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” [27]. Similar results have been reported by Agarwal et al*.,* [23] in broccoli.

4. CONCLUSION

The experimental result revealed that T_4 (D^2S^1) combination of planting time 12th November and wider spacing 45cm × 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.

ACKNOWLEDGEMENTS

The Authors are thankful to Department of Horticulture, SHUATS, Allahabad School of Agriculture, for taking their keep interest and encouragement to carry out the research work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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