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IMPACT OF DIFFERENT SPACING ON GROWTH AND YIELD OF DIFFERENT CULTIVARS OF CAULIFLOWER (*BRASSICA OLERACEA VAR. BOTRYTIS L.*)

Lovejot Kaur*, Navdeep Singh, Gurdeep Singh and Mohit
Department of Horticulture, Faculty of Agriculture, Guru Kashi University, Bathinda -151302 (Punjab), India.
*Corresponding author E-mail: kaurlovejot68@gmail.com
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ABSTRACT

The present investigation titled "Impact of Different Spacing on Growth and Yield of Different cultivars of Cauliflower (*Brassica oleracea var. botrytis L.*)", was conducted at the Horticultural Research Farm of Guru Kashi University, Talwandi Sabo, Bathinda. Two cultivars, Pusa Snowball-1 and PusaKatki, were evaluated under four spacing treatments: 45×10 cm, 45×20 cm, 45×30 cm, and 45×40 cm. Observations were recorded on plant height, number of leaves per plant, days to curd initiation and maturity, curd diameter, individual curd weight, yield per plot and per hectare, and total soluble solids (TSS). Results indicated that both spacing and cultivar significantly affected all traits. Pusa Snowball-1 showed superior performance in curd traits and yield, particularly under 45×40 cm spacing, while 45×20 cm spacing recorded the highest leaf count, early curd initiation, and maximum net returns. The 45×30 cm spacing yielded the highest TSS and ascorbic acid content. Overall, Pusa Snowball-1 at 45×20 cm is recommended for optimal production under Punjab conditions, combining high yield and profitability with favorable quality attributes.

***Keywords*:** Cauliflower, Pusa Snowball-1, Plant Spacing, Growth parameter, TSS.

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is an important cruciferous vegetable crop widely grown in India. It originated in the Mediterranean region of Southern Europe and was introduced to India from England in 1822 by Dr. Jemson (Chatterjee and Swarup, 1972). Cauliflower is a nutritious vegetable, rich in minerals and vitamins, particularly vitamin C and folate. It contains about 90% moisture, 2.6 g protein, 0.4 g fat, and essential minerals like sodium (53 mg), phosphorus (57 mg), potassium (138 mg), calcium (33 mg), magnesium (18 mg), zinc (0.4 mg), iron (1.23 mg), sulphur (231 mg), chromium (0.003 mg), and copper (0.13 mg) per 100 g. It also provides carotene (30 mg), thiamine (0.04 mg), riboflavin (0.1 mg), and niacin (1 mg) (Dhaliwal, 2017).

The availability of high-yielding varieties combined with optimal plant spacing can enhance farmers returns per unit area and improve nutrient uptake and solar energy utilization. Varietal response to plant density varies, influenced by differences in morphology and phenology (Prasad *et al*., 2010). Growth, yield, and quality parameters also differ among cultivars depending on environmental conditions (Thapa *et al*., 2017).

Cauliflower has several varieties, but the Snowball variety shows higher curd yield (Ningawale *et al.*, 2016). However, it is sensitive to changes in planting time (Babu *et al*., 2016). Proper spacing enhances both yield and head size, while wider spacing reduces plant population and total yield. Optimal spacing can increase yield by up to 25%, whereas improper spacing may delay reproductive growth and affect curd quality (Islam *et al*., 2016; Tahima *et al*., 2018). Therefore, selecting the right variety, proper spacing, and timely planting are essential for high yield and better quality.

Plant spacing significantly influences the growth, development, and yield of crops. Closer spacing limits intercultural operations and increases competition among plants for nutrients, air, and light. In contrast, wider spacing promotes vigorous growth, resulting in

larger plants and improved produce quality. (Kaur *et al.,* 2020) This study aims to examine the impact of different cauliflower varieties and plant spacing on growth, yield, and quality. It also evaluates their interaction effects on overall crop performance.

Material and Methods

The current study was carried out at the experimental field of Guru Kashi University Research Farm, Talwandi Sabo (Bathinda) during the winter season of 2024-25. The research farm is situated at a latitude of 29°57'N and a longitude of 75°7'E, with an elevation of 213 meters above sea level.

Experimental design

The field experiment was conducted using a split plot design, comprising two cauliflower varieties Pusa Snowball-1 (V1)and Pusa Katki (V2) as main factor, and four distinct planting spacing S1(45 × 10 cm), S2(45 × 20 cm), S3 (45 × 30 cm) and S4 (45 × 40 cm) as sub factors, to evaluate the effects of spacing and varietal response. The study was carried out in the winter season of 2024, utilizing 24 plots with dimensions of 4 × 2 m² each.

Main Factor- 2 Varieties of Cauliflower (V)

V1- Pusa Snowball-1

V2- Pusa Katki

Sub factor- 4 Planting spacing (S)

S1- 45×30 cm

S2- 45×20 cm

S3-45×40 cm

S4- 45×10 cm

Crop Season-Winter, 2024

Plot size- 4×2 m^2

No. of Plots- 18

Fertilizer Application

Seven days prior to transplanting, 15 t/ha of well-decomposed farmyard manure was incorporated into the soil. Inorganic fertilizers (120 kg N, 60 kg P_2O_5, 60 kg K_2O/ha) were applied using urea, single super phosphate, and muriate of potash. Nitrogen was applied in two splits: half at transplanting and half 30 days later. Data on growth, yield, and quality were recorded from three randomly selected plants per plot, including plant height, days to curd initiation and maturity, curd diameter, leaf number, curd weight, yield, total soluble solids, and nutrient content.

Results and Discussion

Growth Parameters: Analysis of the observations presented in Table 1 revealed that the impact of varieties, plant spacing, and their interaction had a significant effect on the growth of cauliflower. The results demonstrate that different spacing levels significantly influenced the growth parameters of various cauliflower cultivars. Notable improvements were observed in plant height, number of leaves per plant, days to curd initiation, and days to curd maturity.

The study recorded significant differences in plant height influenced by variety, spacing, and their interaction. Pusa Snowball-1 (V1) and the widest spacing (45×40 cm) showed the tallest plants, with V1S2 recording the maximum height (47.663 cm). The shortest plants were found in V2S4 (32.833 cm). These results are in agreement with earlier findings by Giri *et al*. (2013), Zaki *et al*. (2015), Mishra *et al*. (2022), Meena et al. (2022), Singh *et al*. (2022), Shruthy *et al*. (2020), and Bhangre *et al*. (2011).

The number of leaves per plant was significantly influenced by variety, spacing, and their interaction. Pusa Snowball-1 (V1) recorded the highest leaf count (25.210), with spacing S2 (45×20 cm) showing the maximum no. of leaves (25.825). The V1S2 combination had the highest leaf number (26.253), followed by V1S1. These findings align with previous studies by Shruthy *et al.* (2020), Hill (2000), Singh (2005, 2022), Agarkar *et al.* (2010), Pradeep Kumar et al. (2002), Jana and Mukhopadhyay (2006), and Sharma *et al.* (2006).

The number of days to curd initiation varied significantly among the varieties. Pusa Snowball-1 (V1) initiated curd formation the earliest (56.514 days) aligning with the findings of Islam *et al.* (2016). Among the spacing treatments, S1 (45×30 cm) showed the earliest curd initiation (56.088 days), which was statistically at par with S3 (45×40 cm) at 57.575 days. These results are in agreement with the studies of Mishra *et al*. (2022) and Meena *et al*. (2022) in cabbage. The V1S3 treatment combination recorded the minimum days (54.543) to curd initiation, while V2S3 showed the maximum days (60.607).

Curd maturity was significantly affected by variety, spacing, and their interaction. Pusa Katki (V2) matured slightly earlier (70.717 days) than Pusa Snowball-1 (V1), while spacing S3 (45×40 cm) led to the earliest maturity (69.347 days), in agreement with Srivastava *et al.* (2011) and Chabok and Amoli (2013). The V1S3 combination showed the earliest maturity (69.163 days), and V1S2 the latest (72.207 days). These results are consistent with Islam *et al*. (2016),

emphasizing the combined influence of variety and spacing on curd maturity.

PusaKatki (V2) matured slightly earlier (70.717 days) than Pusa Snowball-1 (V1) (70.828 days), corroborating the findings of Srivastava *et al*. (2011) and Chabok and Amoli (2013). Among the spacing treatments, the earliest curd maturity was recorded under S3 (45×40 cm) with 69.347 days, followed by S1 and S2, as reported by Mishra *et al*. (2022) and Meena *et al*. (2022). The interaction effect between variety and spacing was significant, with V1S3 showing the shortest maturity period (69.163 days) and V1S2 the longest (72.207 days), aligning with the results of Islam *et al.* (2016).

Yield parameters: The data presented in Table 2 indicate that the effects of different varieties, plant spacing, and their interaction significantly influenced cauliflower growth. The results reveal that different spacing levels significantly influenced the yield parameters of various cauliflower cultivars. Notable improvements were observed in curd diameter, curd weight, curd yield(kg/plot), curd yield (t/ha).

The highest curd diameter was recorded in variety V1 (Pusa Snowball-1) at 14.701 cm, followed by V2 (Pusa Katki) with 13.917 cm. Among spacing treatments, S3 (45×40 cm) showed the largest diameter (14.513 cm). The V1S3 combination produced the maximum curd diameter (14.943 cm), statistically at par with V1S2 (14.920 cm), while the lowest was observed in V2S4 (13.458 cm). These findings align with earlier reports by Bhangre *et al*. (2011).

Pusa Snowball-1 (V1) showed the highest curd weight (501.61 g), followed by Pusa Katki (V2) with 480.63 g. Among the spacing treatments, the widest spacing (45×40 cm, S3) resulted in the highest curd weight (503.05 g). A significant interaction between variety and spacing was observed, where the V1S3 combination produced the maximum curd weight (521.54 g), and the lowest was recorded in V2S4 (456.04 g). These results are in agreement with the findings of Gabhale *et al*. (2014), Chatterjee (2006), and Muhammad *et al.* (2007), who also reported improved curd weight under wider spacing.

Pusa Snowball-1 (V1) produced the highest curd yield per plot (12.077 kg), followed by Pusa Katki (11.419 kg), consistent with Shruthy *et al.* (2020). Among spacings, S3 (45×40 cm) recorded the highest yield (11.973 kg), statistically similar to S1, while S2 showed the lowest (10.570 kg), as reported by Gabhale *et al*. (2014).The interaction between variety and planting spacing significantly influenced curd yield, with the highest yield recorded in the V1S3 combination (12.500 kg/plot), followed by V1S2 and V2S1 (both 12.237 kg/plot).

The highest curd yield (17.14 t/ha) was recorded in Pusa Snowball-1 (V1), followed by PusaKatki (V2) at 16.269 t/ha, consistent with Mukhopadhyay (2006) who reported similar yields. Among planting spacing S3 (45×40 cm) produced the maximum yield (17.035 t/ha), statistically comparable to S1 (45×30 cm) at 16.573 t/ha, while S2 (45×10 cm) had the lowest yield (15.763 t/ha). A significant interaction between variety and spacing was observed, with V1S3 producing the maximum yield (17.777 t/ha) and V2S4 the minimum (15.467 t/ha), aligning with previous reports by Sharma *et al*. (2011) and Islam *et al.* (2016).

Quality Parameter:

A statistically significant difference was observed in the total soluble solids (TSS) content of cauliflower curds among varieties, with Pusa Snowball-1 exhibiting the highest TSS (5.084) compared to PusaKatki (4.917). However, no significant difference in TSS content was found among different planting spacing (Table 3). The interaction between variety and spacing showed a non-significant effect on TSS content. The combination V1S2 (Pusa Snowball-1 × 45×20 cm) recorded the highest TSS value (5.093), while the lowest was observed in V2S4 (4.546). These findings are consistent with earlier studies by Moratagi *et al*. (2021), Kumar *et al*. (2007), and Zaki *et al*. (2015).

Conclusion

Pusa Snowball-1 exhibited superior performance with the maximum yield. Among the spacing treatments, S3 (45×40 cm) was found to be the most effective in enhancing plant height and yield traits. The interaction of variety and spacing had a synergistic effect, where Pusa Snowball-1 × 45×40 cm recorded the highest curd yield.

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Table 1: Impact of Varieties, plant spacing and their interaction on growth characters of Cauliflower.

Treatment	Plant Height (cm)	No. of Leaves/plant	Days to curd initiation	Days to curd maturity
Factor A		**Varieties**		
Pusa Snowball-1	42.289	25.210	56.514	70.828
PusaKatki	39.377	24.911	57.990	70.717
SEm(±)	0.5	0.818	0.722	0.898
CD (P=0.05)	0.707	1.157	1.020	1.270
Factor B		**Spacing**		
45×30 cm	38.177	25.550	56.088	70.930
45×20 cm	39.492	25.825	58.093	72.040
45×40 cm	44.830	23.807	57.575	69.347
45×10cm	36.824	22.734	57.085	70.885
SEm(±)	1.933	0.867	1.805	1.947
CD (P=0.05)	2.734	1.226	2.553	2.753
Interaction				
(Pusa Snowball-1) × (45×30 cm)	35.563	25.830	56.867	71.113
(Pusa Snowball-1) × (45×20 cm)	47.663	26.253	58.133	72.207
(Pusa Snowball-1) × (45×40 cm)	43.640	23.547	54.543	69.163
Pusa Snowball-1) × (45×10 cm)	44.573	23.264	57.932	70.983
(PusaKatki) × (45×30 cm)	40.790	25.270	55.310	70.747
(PusaKatki) × (45×20 cm)	35.343	25.397	58.053	71.873
(PusaKatki) ×(45×40 cm)	41.997	24.067	60.607	69.530
(PusaKatki) ×(45×10 cm)	32.833	22.250	57.985	70.550
SEm(±)	2.734	1.226	2.553	2.753
CD (P=0.05)	1.35	0.904	1.305	1.355

Table 2: Impact of Varieties, plant spacing and their interaction on growth characters of Cauliflower

Treatment	Curd diameter (cm)	Curd weight (g)	Curd yield (kg/plot)	Curd yield (t/ha)
Factor A		**Varieties**		
Pusa Snowball-1	14.701	501.61	12.077	17.140
PusaKatki	13.917	480.63	11.419	16.269
SEm(±)	0.733	8.718	0.252	0.319
CD (P=0.05)	1.036	12.329	0.356	0.451
Factor B		**Spacing**		
45×30 cm	14.073	484.77	11.692	16.573
45×20 cm	14.340	485.54	11.578	16.505
45×40 cm	14.513	503.05	11.973	17.035
45×10 cm	13.210	475.89	10.570	15.763
SEm(±)	0.259	15.619	0.418	0.598
CD (P=0.05)	0.366	22.089	0.591	0.846
Interaction				
(Pusa Snowball-1) × (45×30 cm)	14.240	476.30	11.493	16.287
(Pusa Snowball-1) × (45×20 cm)	14.920	506.98	12.237	17.357
(Pusa Snowball-1) × (45×40 cm)	14.943	521.54	12.500	17.777
(Pusa Snowball-1) × (45×10 cm)	13.720	489.08	11.056	16.138
(PusaKatki) × (45×30 cm)	13.907	493.25	11.890	16.860
(PusaKatki) × (45×20 cm)	13.760	464.09	10.920	15.653
(PusaKatki) ×(45×40 cm)	14.083	484.55	11.447	16.293
(PusaKatki) ×(45×10 cm)	13.458	456.035	10.207	15.467
SEm(±)	0.366	22.089	0..591	0.846
CD (P=0.05)	0.493	3.837	0.627	0.750

Table 3: Impact of varieties, plant spacing and their interaction on quality characters of Cauliflower curd.

Treatment	TSS (^{0}Brix)
Factor A- Varieties	
Pusa Snowball-1	5.084
PusaKatki	4.917
SEm(±)	0.037
CD (P=0.05)	0.052
Factor B- Spacing	
45×30 cm	5.072
45×20 cm	4.933
45×40 cm	4.997
45×10 cm	4.830
SEm(±)	0.108
CD (P=0.05)	0.153
Interaction	
(Pusa Snowball-1) × (45×30 cm)	5.073
(Pusa Snowball-1) × (45×20 cm)	5.093
(Pusa Snowball-1) × (45×40 cm)	5.087
(Pusa Snowball-1) × (45×10 cm)	5.067
(PusaKatki) × (45×30 cm)	5.070
(PusaKatki) × (45×20 cm)	4.773
(PusaKatki) ×(45×40 cm)	4.907
(PusaKatki) ×(45×10 cm)	4.546
SEm(±)	0.153
CD (P=0.05)	0.319

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