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EFFECT OF DIFFERENT SPACING AND TRANSPLANTING DATES ON THE GROWTH AND YIELD OF MID-SEASON CAULIFLOWER (*BRASSICA OLERACEA* VAR. *BOTRYTIS*) UNDER SUBTROPICAL CONDITIONS OF JAMMU PLAINS OF INDIA

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ABSTRACT

An experiment entitled Effect of different spacing and transplanting dates on growth and yield of cauliflower (*Brassica oleracea* var. *botrytis*) was carried out at the experimental farm, Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, during winter season 2022-2023. The treatment combinations comprised of three dates of transplanting viz., 10th September 2022, 20th September 2022 and 30th September 2022 and three spacing's viz., 60cm × 45cm, 60cm × 60 cm and 60cm × 75 cm in a Split Plot Design with three replications. Study reveals that 20th September was significantly superior to all growth parameters and marketable yield. Among spacing, 60cm × 75cm was significantly superior for all growth and curd parameters except curd yield per hectare. For curd yield per hectare spacing of 60cm × 45cm was found to be significantly superior.
Keywords **:** Cauliflower, Spacing, Transplanting Dates, Curd, Marketable yield

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most important vegetable in India, belonging to the family Cruciferae having chromosome number 2n=2x=18. In India, Cauliflower was introduced from Kew gardens in 1822 by Dr. Jemson. This vegetable is grown for its white tender curd and contain substantial amount of protein, carbohydrates, phosphorus, calcium, iron and ascorbic acid. The optimum temperature for the seed germination is 10°C-25°C and the temperature required for the curd development is 20°C-25°C. Its curds are used as cooked vegetable either singly or mixed with other vegetables. Cauliflower production in India is approximately 9.22 million tonnes from 4.73 million hectares whereas its production in Jammu and Kashmir is 0.93 million tonnes from 3070 hectares of land (Anonymous, 2021).

Cauliflower is generally categorized into different maturity groups which are- early group, medium group and late group. Under subtropical condition, sowing time of medium group is August to September. It is essential to maintain optimum plant spacing for maximum curd yield of cauliflower through efficient utilization of light, nutrients and water by the plants. Increase in the plant density limits the availability of space for lateral growth, resulting in increase in plant height (Pandita *et al*., 2005). Selection of variety and planting at proper spacing are the key elements for high yield and quality of curd production (Islam *et al*., 2016). Wider spacing decrease number of plants as well as overall yield. Hence, it is necessary to optimize proper plant spacing for obtaining higher yield per unit area with better quality. Curd yield is also influenced significantly by the date of planting (Ara *et al*. 2009). If planting is done too early, curd may form before the commencement of chilling temperature resulting in

lower yield and if planting is done late then the temperature becomes very low before the vegetative growth is complete, the plant remains stunted, resulting in low yield of curd. The sowing and transplanting time should be adjusted in such a way that plants put up maximum vegetative growth before the temperature becomes very low. The date of sowing is a vital non-monetary input that plays a significant role in deciding the growth and yield of crops, including that of quality seed production abilities (Stofella and Bryan, 1998). In view of this fact, the present study was undertaken with the aim of examining the optimum spacing and date of transplanting for obtaining higher curd yield with better yield.

Material and Methods

The experiment was carried out the experimental farm of Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences, Jammu in 2022-2023. Treatment comprised of three spacing and three transplanting. Total nine treatments viz., $T_1(S_1D_1)$, $T_2(S_2D_1)$, $T_3(S_3D_1)$, $T_4(S_1D_2)$, $T_5(S_2D_2)$, $T_6(S_3D_2)$, $T_7(S_1D_3)$, $T_8(S_2D_3)$, $T_9(S_3D_3)$. Whereas S_1 = (60cm×45cm), S_2 = (60cm×60cm), S_3 = (60cm×75cm) and D_1 = 10th September 2022, D_2 = 20th September 2022, D_3 = 30th September 2022. The experiment was laid out in Split Plot Design with three replications. Seedlings were transplanted in well prepared plot of 3.00m × 2.40m size at different spacing and different dates of planting. Observations were recorded on plant height, plant frame, number of leaves per plant, leaf length, curd diameter, gross curd weight, net curd weight, curd compactness and curd yield per hectare from randomly selected plants in each treatment.

Result and Discussion

Plant height (cm)

Significant effect of spacing on plant height of mid-season cauliflower is observed as shown in table 1. Maximum plant height of 71.66cm was recorded in the treatment where plants were spaced at 60cm × 75cm (S_3) and lowest plant height of 68.11cm was recorded where plants were spaced at 60cm × 45cm (S_1). Kanasae *et al*. (2018) also observed that varied spacing resulted in highest plant height and it was due to lesser competition for nutrient, moisture and carbon dioxide among the roots of plant. Joshi *et al*. (2018) reported that lesser spacing created more nutrient for resources in the roots of plant and resulted in lower plant height. In case of date of transplanting, non-significant effect on plant height was recorded. Similar results were reported by El-Magd (2013) and El-Yazied *et al*. (2007).

Plant Frame (cm^2)

Significant effect of date of transplanting and spacing on plant frame was observed as shown in table 2. Maximum plant frame of 2969.78 cm^2 was recorded in the treatment where plants were spaced at 60 cm × 75 cm (S_3) and lowest plant frame of 2578.67 cm^2 was recorded in the treatment having plants were spaced at 60 cm × 45 cm (S_1). This might be due to less competition between plants for light and nutrient which led to the maximum plant frame. Similar results were observed by Khatiwada *et al*. (2001). Among different date of transplanting maximum plant frame (2908.22 cm^2) was recorded at 20th September date of transplanting (D_2) and lowest plant frame of 2645.11 cm^2 was recorded at 30th September date of transplanting (D_3). This might be due to better environmental conditions resulting in better vegetative growth. These results are in accordance with Mohanty and Srivastava (2002) and Thirupal *et al*. (2014).

Number of leaves per plant

Significant effect of date of transplanting and spacing on number of leaves per plant was identified as shown in table 3. Maximum number of leaves 19.00 was recorded in the treatment where plants were spaced at 60 × 75 cm (S_3) and lowest number of leaves of 16.11 was recorded in the treatment having plants were spaced at 60 cm × 45 cm (S_1). Higher number of leaves may be due to availability of resources for growth and development of leaves. The more space provides better exposure to plants for photosynthesis. Similar findings were observed by Masoud *et al*. (2003). Among different dates of transplanting, maximum number of leaves 18.66 was recorded at 20th September date of transplanting (D_2) and lowest number of leaves of 16.55 was recorded at 30th September date of transplanting (D_3). Kansae *et al*. (2018) observed that this might be due to favourable climatic situation conquered during the crop period.

Leaf length (cm)

Significant effect of spacing on leaf length of mid-season cauliflower was investigate as shown in table 4. Maximum leaf length of 65.66 cm was recorded in the treatment where plants were spaced at 60 cm × 75 cm (S_3) and lowest leaf length of 62.11 cm was recorded where plants were spaced at 60 cm × 45 cm (S_1). In case of date of transplanting, non-significant effect on leaf length was recorded. Kanasae *et al*. (2018) also observed that varied spacing resulted in highest plant height and it was due to lesser competition for nutrient, moisture and carbon dioxide among the roots of the plant. Joshi *et al*. (2018) reported that lesser spacing

created more competition for resources in the roots of plant and resulted in lower leaf length.

Leaf width (cm)

Significant effect of date of transplanting and spacing on leaf width was detected as shown in table 5. Maximum leaf width of 30.65 cm was recorded in the treatment where plants were spaced at 60 cm × 75 cm (S_3) and lowest leaf width of 27.43 cm was recorded in the treatment where plants were spaced at 60 cm × 45 cm. This might be due to plant with wider spacing received more sunlight and nutrients due to less plant density which enhanced vegetative growth of plant hence wider leaves were obtained. Similar results were observed by (Moniruzzaman, 2011). Among different date of transplanting maximum leaf width (30.77 cm) was recorded at 20th September date of transplanting (D2) and lowest leaf width (27.75 cm) was recorded at 30th September date of transplanting (D3). This might be due to better environmental conditions resulting in better vegetative growth which led to maximize leaf width.

Curd diameter (cm)

Significant effect of date of transplanting and spacing on curd diameter was noticed as shown in table 6. Maximum curd diameter of 25.12 cm was recorded in the treatment where plants were spaced at 60 cm × 75 cm (S_3) and lowest curd diameter of 20.17 cm was recorded at 60 cm × 45 cm. Oad *et al*. (2002) observed that the closer spacing showed poor results due to closer competition for acquiring the nutrients, sunlight and space for better growth and development. He also reported that narrow plant spacing resulted in poor plant qualities. Among different date of transplanting maximum curd diameter of 23.91 cm was recorded in the treatment where plants were transplanted on 20th September (D_2) and lowest curd diameter of 20.29 was recorded at 30th September date of transplanting (D_3). Maximum curd diameter at this time may be due to optimum time of transplanting providing suitable temperature and climatic conditions. Similar results were found by Singh *et al*. (2015).

Gross curd weight (g)

Significant effect of date of transplanting and spacing on gross curd weight was experienced as shown in table 7. Maximum gross curd weight of 1433.67 g was recorded in the treatment where plants were spaced at 60 cm × 75 cm (S_3) and lowest gross curd weight of 1195.44 g was recorded in the treatment where plants were spaced at 60 cm × 45 cm and it is may be due to proper utilization of accumulates which were conserved by the plants which were optimally spaced. The results are in close proximity with Oad *et al*. (2002) and Abed *et al*. (2015). Among different date of transplanting maximum gross curd weight of 1384.44 g was recorded at 20th September date of transplanting (D_2) and lowest gross curd weight of 1270.44 g was recorded at 30th September date of transplanting (D_3). Similar findings were observed by Kumar *et al*. (2019) in cabbage.

Net curd weight (g)

Significant effect of date of transplanting and spacing on net curd weight was recognized as shown in table 8. Maximum net curd weight of 896.66 g was recorded in the treatment where plants were spaced at 60 cm × 75 cm (S_3) and lowest net curd weight of 670.44 g was recorded in the treatment where plants were spaced at 60 cm × 45 cm. This might be due to cauliflower crop planted at wider spacing received efficient nutrients, light and moisture as compared to the plants grown at closer spacing, which resulted in better performance for growth and other yield contributing traits. Similar findings were observed by Kumar *et al*. (2019) and Chatterjee in (2006). Among different date of transplanting maximum net curd weight of 830.22 g was recorded at 20th September date of transplanting (D_2) and lowest net curd weight of 748.55 g was recorded at 30th September date of transplanting (D_3). Similar findings were observed by Kumar *et al*. (2019) in cabbage.

Curd Compactness

Significant effect of date of transplanting and spacing on curd compactness was noted as shown in table 9. Maximum curd compactness of 67.72 was recorded in the treatment where plants were spaced at 60 cm × 75 cm (S_3) and lowest net curd compactness of 51.06 was recorded in the treatment where plants were spaced at 60 cm × 45 cm. Khatiwada *et al*. (2001) observed that increase in plant population decrease the head compactness of cabbage up to a certain level. Among different date of transplanting maximum curd compactness of 62.65 was recorded at 20th September date of transplanting (D_2) and lowest net curd compactness of 57.99 was recorded at 30th September date of transplanting (D_3). This might be due to differences in genetic constituents of the variety and variation in climatic parameters during the growing periods.

Curd yield / ha (q)

Significant effect of date of transplanting and spacing on curd yield was recognized as shown in table 10. Maximum curd yield / ha of 232.79 quintal was recorded in the treatment where plants were spaced at 60 cm × 45 cm (S_1) and lowest net curd yield of 186.80 quintal was recorded in the treatment where plants

were spaced at 60 cm × 75 cm. This might be due to closer spacing between the plants as there were a greater number of plants in closer spacing as compare to the rest of the treatments. Similar results were reported by Rahman *et al*. (2007) in cauliflower and Hossain *et al*. 2012 in broccoli. Among different dates maximum curd yield / ha of 226.07 quintal was recorded at 20th September date of transplanting (D_2) and lowest net curd yield of 202.46 quintal was recorded at 30th September date of transplanting (D_3) This might be due to better climatic conditions during vegetative growth which resulted in greater photosynthetic activity. Similar results were observed by Singhal *et al*. (2009), Saikia *et al*. (2010).

Table 1: Effect of spacing and date of transplanting on plant height in mid-season cauliflower

Plant height (cm)				
	S1	**S2**	**S3**	**Mean D**
D1	68.00	69.00	72.00	**69.66**
D2	70.00	71.00	74.00	**71.66**
D3	66.33	66.83	69.00	**67.38**
Mean S	**68.11**	**68.94**	**71.66**	
	SE(m)		**C.D**	
S	**0.50**		**1.57**	
D	**0.88**		**NS**	

Table 2: Effect of spacing and date of transplanting on plant frame in mid-season cauliflower

Plant frame (cm^2)				
	S1	**S2**	**S3**	**Mean D**
D1	2570.33	2784.00	3007.00	**2787.11**
D2	2610.67	2945.33	3168.67	**2908.22**
D3	2555.00	2646.67	2733.67	**2645.11**
Mean S	**2578.67**	**2792.00**	**2969.78**	
	SE(m)		**C.D**	
S	**75.51**		**157.54**	
D	**21.89**		**88.26**	

Table 3: Effect of spacing and date of transplanting on number of leaves per plant in mid-season cauliflower

Number of leaves per plant				
	S1	**S2**	**S3**	**Mean D**
D1	16.00	17.66	19.00	**17.55**
D2	17.00	19.00	20.00	**18.66**
D3	15.33	16.33	18.00	**16.55**
Mean S		**17.66**	**19.00**	
	SE(m)		**C.D**	
S	**0.24**		**0.74**	
D	**0.23**		**0.93**	

Table 4: Effect of spacing and date of transplanting on leaf length in mid-season cauliflower

Leaf Length (cm)				
	S1	**S2**	**S3**	**Mean D**
D1	62.00	63.00	66.00	**63.66**
D2	64.00	65.00	68.00	**65.66**
D3	60.33	60.83	63.00	**61.38**
Mean S	**62.11**	**62.94**	**65.66**	
	SE(m)		**C.D**	
S	**0.50**		**1.57**	
D	**0.88**		**NS**	

Table 5: Effect of spacing and date of transplanting on leaf width in mid-season cauliflower

Leaf width(cm)				
	S1	**S2**	**S3**	**Mean D**
D1	26.96	28.00	30.33	**28.43**
D2	29.06	31.13	32.13	**30.77**
D3	26.26	27.50	29.50	**27.75**
Mean S	**27.43**	**28.87**	**30.65**	
	SE(m)		**C.D**	
S	**0.26**		**0.83**	
D	**0.10**		**0.43**	

Table 6: Effect of spacing and date of transplanting on curd diameter in mid-season cauliflower

Curd diameter (cm)				
	S1	**S2**	**S3**	**Mean D**
D1	20.30	21.40	26.03	**22.58**
D2	20.66	23.20	27.86	**23.91**
D3	19.55	19.86	21.46	**20.29**
Mean S	**20.17**	**21.49**	**25.12**	
	SE(m)		**C.D**	
S	**0.27**		**0.86**	
D	**0.13**		**0.55**	

Table 7: Effect of spacing and date of transplanting on gross curd weight in mid-season cauliflower

Gross curd weight (g)				
	S1	**S2**	**S3**	**Mean D**
D1	1190.00	1298.33	1417.67	**1302.00**
D2	1240.00	1400.00	1513.33	**1384.44**
D3	1156.33	1285.00	1370.00	**1270.44**
Mean S	**1195.44**	**1327.78**	**1433.67**	
	SE(m)		**C.D**	
S	**11.57**		**36.05**	
D	**2.54**		**10.26**	

Table 8: Effect of spacing and date of transplanting on net curd weight in mid-season cauliflower

Net curd weight (g)				
	S1	**S2**	**S3**	**Mean D**
D1	640.00	755.00	886.66	**760.55**
D2	737.33	820.00	933.33	**830.22**
D3	634.00	741.66	870.00	**748.55**
Mean S	**670.44**	**772.22**	**896.66**	
	SE(m)		**C.D**	
S	**9.94**		**30.98**	
D	**8.12**		**32.76**	

Table 9: Effect of spacing and date of transplanting on curd compactness in mid-season cauliflower

Curd compactness				
	S1	**S2**	**S3**	**Mean D**
D1	50.43	60.00	68.00	**59.47**
D2	52.66	64.00	71.30	**62.65**
D3	50.10	60.00	63.88	**57.99**
Mean S	**51.06**	**61.33**	**67.72**	
	SE(m)		**C.D**	
S	**75.51**		**157.54**	
D	**21.89**		**88.26**	

Table 10: Effect of spacing and date of transplanting on curd yield per ha (q) in mid-season cauliflower

curd yield per ha (q)				
	S1	**S2**	**S3**	**Mean D**
D1	222.22	209.71	184.72	**205.55**
D2	256.01	227.77	194.44	**226.07**
D3	220.13	206.01	181.24	**202.46**
Mean S	**232.79**	**214.50**	**186.80**	
	SE(m)		**C.D**	
S	**2.67**		**8.33**	
D	**2.54**		**10.25**	

Note: D denotes date of transplanting, $\mathbf{D_1}$ = 10th September $\mathbf{D_2}$ = 20th September $\mathbf{D_3}$ = 30th September
S denotes Spacing, $\mathbf{S_1}$ = 60cm × 45cm $\mathbf{S_2}$ = 60cm × 60cm $\mathbf{S_3}$= 60cm × 75cm

Conclusion

It can be concluded that spacing of 60 cm × 75 cm proved to be significantly superior for all the characters except curd yield/ha which was recorded when plants were spaced at 60 cm × 45 cm because of greater number of plants in closer spacing as compared to other spacing whereas amongst dates of transplanting 20th September transplanting performed better with respect to most of the marketable yield characters under study Before 20th September, transplanting was not possible because of high temperature in Jammu subtropical plains. After 20th September, there is prevalence of frost during curd development period.

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