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RESEARCH ARTICLE

EFFECT OF DIFFERENT SPACING AND TRANSPLANTING DATES ON THE GROWTH AND YIELD OF CAULIFLOWER (*Brassicae oleracea* var. *botrytis* L.)

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Abstract

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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, Faculty of Agricultural Sciences, DAV University, Jalandhar during 2019. The treatment combinations comprised of three dates of planting viz., 6th November, 23th November and 8th December and three spacing's viz., 45×50cm, 50 x 50 cm and 50 x 60 cm in a Randomized Block Design (RBD) with three replications. The cauliflower transplanted on the 2nd date of planting i.e. 23th November reported significantly maximum yield (9.03kg) over the other dates of planting, while spacing 50 x 60 cm showed significantly maximum growth for height, number of leaves, stem diameter. Whereas, the maximum number of days taken to curd initiation (114.33) and maturity (14.66) was recorded from 45cm×50cm spacing with 8th November transplanting dates. It can be concluded that the wider spacing gave best results for number of leaves per plant, plant height, stem diameter, curd diameter and yield. Interaction effect of spacing and transplanting datesresulted significance difference for all the character under study except plant height and number of days to curd maturity. It was observed that plants sown on 23 November resulted in superior performance for most of the traits studied. Among spacing, desirable results were observed at closer spacing of 50 cm × 50 cm. Considering the interaction of sowing dates and spacing it was found that plants sown on 23 November with the spacing of 50 cm × 50 cm can resulted in superior performance with respect to growth and yield parameters of cauliflower.

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Introduction:-

Cauliflower (*Brassica oleracea* L. var. *botrytis*) belongs to the family Brassicaceae is an exotic vegetable crop. It is one of the most popular winter vegetable crops and is also called as queen of winter. Cauliflower like other cole crops prefers cool moist climatic conditions which help in the developing quality curd. It is grown in tropical and temperate region of the world. Cauliflower is a cool season crop and shows negative reaction to high temperature. 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. Cauliflower were transmitted from Europe and spread worldwide whereas India occupies first position in the production of cauliflower. In India, Cauliflower was presented from Kew in 1822

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through Dr. Jemson (Kaur *et al*., 2018). Bihar, U.P. Orissa, West Bengal, Assam, Haryana, and Maharashtra these are the major producing states of cauliflower (Gaikwad *et al*., 2018). The total global area under cauliflower is 204.29 million hectare and global production is 2764.39 million tonnes (Anonymous, 2018). In India, cauliflower is cultivated over an area of 460 thousand hectares with annual production of 9174 thousand million tonnes and productivity of 20 MT/hectare (Anonymous, 2019a). In Punjab, cauliflower is grown in an area of about 18.24 thousand hectare with annual production of 214.48 thousand million tonnes and productivity of about 11.76 t/ha (Anonymous, 2019 b).

Transplanting time plays an important role in improving the productivity of curd and yield of cauliflower. Spacing within the plants helps in proper growth and development. Closer spacing would be economically profitable for cauliflower production (Hossain *et al*., 2015). According to recent field tests, wider spacing contributes towards larger and heavier curd while, yield per hectare can be increased by close spacing. The seasonal crop varieties of cauliflower are divided into three class's i.e. early, mid, and late season crop varieties. Cauliflower has many varieties but snowball variety gave higher yield of curds (Rahman *et al*., 2016). Snowball fails to give best performance if there are slightly changes in the planting time (Babu *et al*., 2016). Spacing of plant increase both total yield and size of heads. Selection of variety and planting at proper time are the key element for high yield and quality of curd production (Islam *et al*., 2016).Crop yield may be increased up to 25% by using optimum spacing. Sometimes it detains to generative growth and decrease yield quality. Wider spacing decrease number of plants as well as yield (Tahima *et al*., 2018). Hence, it is necessary to optimize proper plant spacing for obtaining higher yield with better quality.

Research Methods:-

The experiment was carried out the experimental farm of Department of Agricultural Science, DAV University, Jalandhar in 2019-2020. Treatment comprised of three planting and three spacing. Total nine treatments viz., T_1(D1×S1), T_2(D1×S2), T_3(D1×S3), T4(D2×S1), T_5(D2×S2), T_6(D2×S3), T_7(D3×S1), T_8(D3×S2), T_9(D3×S3). Whereas S1 = (45cm×50cm), S2 = (50cm×50cm), S3 = (50cm×60cm) and D1 = 6 November 2019, D2 = 23 November 2019, D3 = 8 December 2019. The experiment was laid out in Randomized Block Design with three replications. Seedlings were transplanted in 3 x 4m m plots at different spacing and different dates of planting. Observations were recorded on plant height, number of leaves, stem diameter and curd yield from randomly selected plants in each treatment.

Research Findings and discussion

Number of leaves per plant

Number of leaves per plant was significantly influenced by different treatments. Among the different transplanting dates and spacing, treatment T3 (14.78) recorded highest number of leaves/plant and the lowest number of leaves recorded in treatment T1 (12.67). (Hasan *et al*. 2018) reported that the number of leaves also plays an important role in energy transformation, activation of a number of enzymes, carbohydrate metabolism and chlorophyll formation. (Kansae *et al*. 2018) who observed, this might be due to favorable climatic situations conquered during the crop period. The results revealed that the increase in spacing and transplanting dates have significantly increased the number of leaves per plant.

Among interaction effects (Table 1.3) highest number of leaves per plant (15.70) was observed in D2 × S2 (23 November × 50 cm × 50 cm) which was statistically at par with D2 × S1 (23 November × 45 cm × 50 cm) 19.26, D2×S3 (23 November × 50 cm × 60 cm) 19.13, and D1 × S3 (8 November × 50 cm × 60 cm) 18.96. Lowest number of leaves per plant (15.36) were observed in D1×S1 (8 November × 45 cm × 50 cm) which was statistically lowest among all the dates. Similar results were obtained by Kabir *et al*. (2013) and Lavanya *et al*. (2017) at different environmental conditions. Leaf

Plant height (cm)

Plant height of cauliflower was significantly influenced by different treatments. Among the different transplanting dates and spacing, treatment T6 (30.29) cm recorded highest plant height and treatment T2 (28.46) cm recorded lowest plant height. (Hasan *et al*. 2018) reported that the difference in plant height as partial by spacing was possibly due to proper utilization of nutrients, moisture and light. During the growing period plant height gradually increased with time and reached to the maximum at harvest. (Kansae *et al*. 2018) who observed, that the varied spacing resulted in the highest plant height and was due to smaller competition for nutrients, moisture, and CO_2 among the roots of the plants. In contradiction to this, (Joshi *et al*. 2018) who reported that the smaller spacing created more competition for the resources in the roots of plants and resulted in lower plant height. The more space also provides the better exposure to plants for photosynthesis. The present investigation is in close conformity with the finding of Singh *et al*. (2019).

Interaction effect of spacing and transplanting dateson plant height was not significant (Table 1.3). Non significant differences for plant height among interaction effect of spacing and transplanting datesunder different climatic conditions by earlier researchers viz., Sahu *et al*. (2018) and also disagreed with Moratagi *et al*., (2021).

Stem Diameter (cm)

Treatment T4 (8.96) cm recorded highest stem diameter and treatment T9 (6.26) cm recorded lowest stem diameter. The results showed that diameter of stem increased significantly due to increasing levels of spacing (wider spacing) and decreased at closer spacing (Table 1.1). Neupane *et al*. (2020) observed that the closer plant spacing show poor results due to closely competition acquiring the nutrients sunlight and space for better stem growth and development. The results of stem diameter found in the contradiction with (Ara *et al*. 2016).

It was observed that stem diameter (8.76cm) was observed in plants grown in interaction D2×S1 (23 November × 45 cm × 50 cm) which was statistically at par with the stem diameter of plants raised in D1×S2 (8 November × 50 cm × 50 cm) and D1×S1 (8 November × 45 cm × 50 cm) which produced the plants with stem diameter of 8.73 cm and 8.26 cm, respectively. Smallest stem diameter (7.10 cm) was observed in D3×S2 (8 December × 50 cm × 50 cm). This was statistically at par with stem diameter of D3×S1 (8 December × 45 cm × 50 cm) 7.93 (Table 1.4). This is in line with the findings of Madumathi *et al*., (2017) who also observed significant interaction effect of spacing and transplanting dateson stem diameter.

Curd Diameter (cm)

Treatment T3 (18.20) cm recorded highest curd diameter and treatment T2 (16.36) cm recorded lowest curd diameter. (Joshi *et al*., (2018) who found that curd diameter is an important yield factor in cauliflower and Superior diameter of curd signifies the higher yield of the crop. (Rahman *et al*., 2007) also reported that the size and weight of curd decreased with the increasing the density.

Highest Curd diameter (17.90) cm was produced by plants grown in interaction D2×S1 (23 November × 45 cm × 50 cm) which was statistically highest among all the treatments. Lowest Curd diameter (16.16) was observed in D3×S1 (8 December × 45 cm × 50 cm) interaction which was significantly lower than the curd diameter produced by plants grown in other interactions (Table 1.4). The findings corroborates with the finding of Moratagi *et al*., (2021), Shruthy *et al*., (2020) and Archana *et al*., (2019).

Number of days taken to curd initiation

The significant variations in growth and development of cauliflower further led to marked variations in its yield attributes. Treatment T5 (78.33) took minimum days for curd initiation and maximum days at T7 (114.33). Suthar *et al*., (2017) which were in agreement with the present findings, the spacing are important characteristic to know the variation of different parameters performance of a crop. Proper spacing in cauliflower reduce the days which are require for initiation of curd and marketable maturity of curd and also decrease the percentage of it. The results are in contradiction with Mujeeb-Ur-Rahman *et al*., (2007).

Significant effect of interaction of spacing and transplanting dateswas observed for number of days taken to curd initiation (Table 1.5). Highest number of days taken to curd initiation (100.33) was observed in D3×S1 (8 December × 45 cm × 50 cm) interaction which was significantly higher than the interaction in all number of days taken to curd initiation other treatment combination. Minimum number of days taken to curd initiation of days was found in D1×S1 (8 November × 45 cm × 50 cm) which is significantly lowest among all the treatments. The contradictions are in accordance to the finding of Shruthy *et al*., (2020).

Number of days taken to curd maturity:

Treatment T2 and T4 took minimum days (10.00) for curd maturity and treatment T7 (14.66) took maximum days for curd maturity. Suthar *et al*. (2017) which were in agreement with the present findingsthe right time of maturity was observed in closest spacing. In wider spacing, plants take more time to complete their physical and biological activities due to more availability of space, sunlight and fertilization. When the time taken for initiation of curd is reduced, the days taken to marketable maturity are also reduced in closer spacing.

Non significant differences were found in number of days taken to curd maturity among interaction effect of spacing and transplanting datesunder different climatic conditions. This finding was disagreed with Islam *et al*., (2016).

Weight of curd (gm):
Significant variations were observed for the weight of curd. Treatment T4 (190gm) recorded maximum weight of curd and treatment T1 (80 gm) recorded lowest curd weight. Singh *et al*., (2019) observed that the increase in yield of cauliflower at closer spacing was due to more number of plants accommodated in a given area. Wide spacing led to low yields due to low plant population per unit area, but curd quality was improved as size of the fruit was bigger and curd weight was higher.

Highest curd weight (190.00 g) was produced by plants grown in interaction D2×S1 (23 November × 45 cm × 50 cm) which was statistically highest among all the treatments. Lowest curd weight (80.00 g) was observed in D1×S1 (8 November × 45 cm × 50 cm) interaction which was significantly lower than the curd weight produced by plants grown in other interactions (Table 1.6). The findings corroborates with the finding of Islam *et al*., (2016), Moratagi *et al*., (2021) and Shruthy *et al*., (2020).

Yield per plot (kg):
The cauliflower yield increased with an increase in plant spacing up to an absolute limit, treatment T4 (9.03 kg) recorded highest yield per plot. Suthar *et al*. (2017) who observed that, by increasing the spacing, total yield of cauliflower decreased significantly (Table 1.1). The interaction of November 23 transplanting dates of resulted in highest yield per plot (kg) (9.04g) and minimum interaction was found in D3×S3 (8 December × 50 cm × 60 cm) which was significantly at par with the other treatment i.e. D1×S1 (8 November × 45 cm × 50 cm) . Similar higher yield was reported by several workers confirming to the present findings (Moratagi *et al*., (2021); Shruthy *et al*., (2020); Islam *et al*., (2016);

Relative economics:
Relative economics of different spacing and transplanting dates was worked out to evaluate the most beneficial treatment in cauliflower relative economics in cauliflower was calculated on yield basis reveals that treatment T4 recorded the maximum Gross returns of the order of Rs. 4,19,240 Rs/ha followed by treatment T3. Amongst different transplanting dates and spacing, highest net returns of Rs.324630 were obtained with treatment T4 followed by treatment T3, whereas the lowest net returns of Rs.114170 Rs/ha was obtained with treatment T9. Among the different spacing and transplanting datestreatments, treatment T4 recorded the maximum benefit cost ratio of 4:3. Whereas the lowest benefit cost ratio (1:2) was obtained with treatment T1. The results found in the conformity of Devi *et al*.(2018), Singh *et al*.(2018), Ola *et al*.(2019).

Table 1.1:- Effect of different spacing and transplanting dateson the growth and yield of cauliflower.

Treatments	Number of leaves per plant	Plant Height (cm)	Stem Diameter (cm)	Curd Diameter (cm)	Number of days taken to curd initiation	Number of days taken to curd maturity	Weight of Curd (g)	Yield per plot (kg)
T_1	12.67	29.81	7.63	17.46	92.66	12.33	80	4.91
T_2	13.88	28.46	8.80	16.36	101.00	10.00	125	5.81
T_3	14.78	29.62	7.40	18.20	94.66	10.33	170	7.97
T4	14.65	29.24	8.96	17.36	84.33	10.00	190	9.03
T_5	14.76	28.95	7.60	18.03	78.33	12.00	115	5.25
T_6	14.55	30.29	7.66	16.93	103.66	11.00	125	5.93
T_7	13.05	29.16	8.73	16.50	114.33	14.66	120	5.37
T_8	13.27	28.97	7.10	16.73	107.00	12.33	90	4.56
T_9	13.86	28.51	6.26	16.46	95.00	11.33	85	4.51
S.E. (m±)	0.47	0.3	0.17	0.26	1.02	0.65	11.95	0.39
C.D. (5%)	1.45	0.92	0.51	0.80	3.10	1.97	3.10	1.97
C.V.	5.8	1.82	3.78	2.68	1.83	9.78	1.83	9.78
S.E.(d)	0.67	0.43	0.24	0.37	0.24	0.37	0.24	0.37

Table 1.2:- Effect of different spacing and transplanting dateson relative economics of cauliflower at periodic intervals.

Treatments	Cost of cultivation(Rs/ha)	Gross return(Rs/ha)	Net return(Rs/ha)	B:C Ratio
T_1	94610	227300	132690	1:2
T_2	94610	268980	174370	1:4
T_3	94610	368980	274370	1:3
T4	94610	419240	324630	4:3
T_5	94610	243040	148430	2:5
T_6	94610	274520	179910	2:9
T_7	94610	248720	154110	1:3
T_8	94610	211100	116490	2:3
T_9	94610	208780	114170	2:3
Treatments	**Cost of cultivation(Rs/ha)**	**Gross return(Rs/ha)**	**Net return(Rs/ha)**	**B:C Ratio**
T_1	94610	227300	132690	1:2
T_2	94610	268980	174370	1:4
T_3	94610	368980	274370	1:3
T4	94610	419240	324630	4:3
T_5	94610	243040	148430	2:5
T_6	94610	274520	179910	2:9
T_7	94610	248720	154110	1:3
T_8	94610	211100	116490	2:3
T_9	94610	208780	114170	2:3

Table 1.3:- Interaction effect of spacing and transplanting dateson leaves per plant and Plant height (cm) of cauliflower.

Transplanting dates	Leaves per plant				Plant height (cm)			
	Spacing							
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
D_1	15.36	18.03	18.96	17.45	33.30	33.13	33.63	33.35
D_2	19.26	19.53	19.13	19.31	34.89	33.33	34.36	34.17
D_3	17.63	17.56	18.96	18.05	32.90	34.60	33.50	33.66
Mean	17.42	18.37	19.02		33.67	33.68	33.83	
Interaction effect								
	D	S	DS		D	S	DS	
CD at 5%	1.39	N/A	N/A		N/A	N/A	N/A	
SD (d)	0.65	0.65	1.13		0.78	0.77	1.34	

Table 1.4:- Interaction effect of spacing and transplanting dateson stem diameter (cm) and curd diameter (cm) of cauliflower.

Transplanting dates	Stem diameter (cm)				Curd diameter (cm)			
	Spacing							
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
D_1	8.26	8.73	8.06	8.36	17.26	17.36	17.50	17.37
D_2	8.76	7.50	7.66	7.97	17.90	17.20	16.60	17.23
D_3	7.93	7.10	6.70	7.24	16.16	16.73	16.46	16.45
Mean	8.32	7.77	7.47		17.11	17.10	16.85	
Interaction effect								
	D	S	DS		D	S	DS	
CD at 5%	0.85	NS	NS		0.15	0.05	0.03	
SD (d)	0.39	0.39	0.68		0.55	0.55	0.95	

Table 1.5:- Interaction effect of spacing and transplanting dateson number of days taken to curd initiation and number of days taken to curd maturity of cauliflower.

Transplanting dates	Number of days taken to curd initiation				Number of days taken to curd maturity			
	Spacing							
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
D_1	84.33	93.33	98.33	92.0	12.67	12.00	14.00	12.89
D_2	90.00	92.66	99.66	94.11	11.33	12.00	12.33	11.88
D_3	100.33	97.00	96.66	98.00	11.33	12.00	11.33	11.55
Mean	91.56	94.33	98.22		11.78	12.00	12.56	
Interaction effect								
	D	S	DS		D	S	DS	
CD at 5%	0.69	NS	NS		NS	NS	NS	
SD (d)	8.56	8.56	14.82		0.73	0.73	1.26	

Table 1.6:- Interaction effect of spacing and transplanting dateson curd weight (g) and yield per plot (kg) of cauliflower.

Transplanting dates	Curd weight (g)				Yield per plot (kg)			
	Spacing							
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
D_1	80.00	125.00	170.00	125.00	4.91	5.85	7.95	6.24
D_2	190.00	115.00	125.00	143.00	9.04	5.28	5.92	6.74
D_3	120.00	90.00	85.00	98.33	5.37	4.56	4.50	4.81
Mean	130.00	110.00	126.66		6.44	5.23	6.13	
Interaction effect								
	D	S	DS		D	S	DS	
CD at 5%	1.01	1.00	1.73		0.43	0.42	0.74	
SD (d)	0.46	0.47	0.81		0.20	0.20	0.35	

Conclusion:-

Spacing of cauliflower on (50×60) cm and 8th December proved significant for number of leaves and curd diameter. (50×45) cm and 6th November gave best results for stem diameter, weight of curd, and yield per plot (50×60) cm and 23th November proved significant for plant height. (50×45) cm and 8th December gave best results of curd initiation and curd maturity. The highest benefit cost ratio was obtained with treatment T4. Hence, from the present study it can be concluded that 6th November transplanting is the optimum time for cauliflower production. Before November, transplanting was not possible because of high temperature in Jalandhar. Besides, 45 x 50 cm and 50 x 60cm plant spacing in-creased statistically similar yield of cauliflower. Further studies are needed to optimize the specific time and plant spacing for the highest yield of cauliflower.

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