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Original Research Article

Effect of Sowing Date and Plant Spacing on Yield and Economics of Seed Production of Early Cauliflower *var. Sabour agrim*

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A B S T R A C T

Present investigation was framed with four sowing date (25thJuly, 10thAugust, 26thAugust and 10th September) and four plant spacing (50 × 40 cm, 50 × 50 cm, 60 × 50 cm and 60 × 60 cm) having 16 treatment combinations. The experiment was laid out in Factorial Randomize Block Design and replicates thrice. The result of the present investigation indicates that the main effect of date of sowing and plant spacing as well as their interaction effect were found significant. . The significantly highest plant height (63.93cm), leaf area (97.00cm^2), polar diameter (10.3cm) and equatorial diameter (21.20cm) were recorded on 10th August and seedlings were transplanted at spacing of 60 × 60cm. Significantly maximum number of branches/plant, number of siliqua/plant, Number of seed/siliqua, seed yield/plant, seed yield (q/ha) and 1000 seed weight were obtained when sowing was done on 10th August and transplanted at spacing of 60 × 60cm. The highest gross income (Rs. 13, 07,800), net income (Rs. 11, 36, 567/ha) and benefit-cost ratio (6.64) were recorded on 10th August and seedlings were transplanted at spacing of 60 × 60cm. Therefore, it may be concluded that combined effect of sowing date (10th August) and plant spacing (60 × 60cm) was the most effective treatment combination for growth, seed yield and economics of seed production of early cauliflower.

Keywords

Cauliflower, Yield, Economics, Seed production

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most important vegetable in India and belongs to the family cruciferae. It is comparatively easy to grow seeds of cauliflowers as it is well adapted to warm weather conditions, some seeds of which were raised in North Indian plains (Lancaster, 1943; Raula, 1949 and Singh, 1955). The regions where early cauliflower seeds are commonly produced are Uttar Pradesh and Bihar. The main reason for its low productivity of curd and seed yield of cauliflower is non availability of high yielding varieties and lack of appropriate production technology especially planting density and time of sowing suiting to different climatic zones and regions. It is highly sensitive to temperature variations and slight variation in temperature may cause complete crop failure and low yield and productivity. Traditionally cauliflower is planted at a wider spacing resulting into low productivity. The planting density and time of sowing play an important role in improving the productivity of curd and quality seed yield of cauliflower. The sowing and transplanting time should be adjusted in such a manner that plants put up maximum vegetative growth before the temperature goes very low. Date of sowing is an important non-monitory input which plays an important role in deciding growth and yield of crops.

All the physiological processes in the plants other than photochemical depend on temperature modification in environment by sowing date, gave a great opportunity of getting optimum temperature at the time of germination and subsequent growth stages to maximize the production. Plant density can have pronounced influence on plant development, growth and marketable yield of many crops (Stofella and Bryan, 1998). Optimum plant spacing is an agronomic factor which plays a vital role in achieving the potential yield of a crop by creating optimum growing environment for growth and development that results in better yield attributes (Singh *et al.*, 2002). Optimizing light interception through manipulation of plant spacing directly influences the plant physiology, growth and yield. Hence the present experiment was conducted to explore the production of better quality of seed with higher yield.

Material and Methods

The present experiment entitled "Effect of sowing date and plant spacing on seed yield of early cauliflower (*Brassica oleracea* var. *botrytis* L.) cv. Sabour Agrim" was designed and laid out in the vegetable research farm of Bihar Agricultural College, Sabour, Bhagalpur during the *kharif* season of 2016-17. The design of the experiment was Factorial Randomize Block Design and replicated thrice. Seeds were sown and covered with thin layer of soil mixed with FYM. There after the bed was covered with paddy straws. Twenty five days old seedlings were used for transplanting in the main field. The soil and the weather condition prevailing during the period of investigation was close to normal for the place and could be termed congenial for growth and development of cauliflower. The treatment comprised of four date of sowing (D_1- 25th July 2016, D_2- 10th August 2016, D_3-26th August 2016, D_4- 10th September) and four plant spacing (S_1-50×40cm, S_2-50×50cm, S_3-60×50cm, S_4-60×60cm) in different combinations. Half dose of nitrogen as urea with full dose of phosphorus (P_2O_5) as single super phosphate and potash (K_2O) as murate of potash were applied before planting of seedling as basal dressing as per the treatment specification. The desired quantity of fertilizers as per treatments were mixed thoroughly and the mixture was placed and incorporated in the top 6-8 layer of soil on the point marked for transplanting of each seedlings.

After placement and incorporation of the fertilizer mixtures, seedlings were transplanted. Five plants in each treatment combination and each replication were randomly selected and tagged properly for recording various observations. The observation recorded for the aforesaid five plants were worked out to give mean in respect of all the characters, *viz*. plant height (cm), leaf area (cm^2), days to 50% curd initiation, curd polar diameter (cm), curd equatorial diameter (cm), days to 50% flowering, number of bolters/plant, numbers of Siliqua /plant, number of seed/plant, days to harvest of seed, test weight (1000 seed wt.), seed yield/plant (g), seed yield (q/ha), gross income (Rs.), net income (Rs.), benefit-cost ratio. The statistical analysis of the data recorded in all observations was carried out by the method of "Analysis of the variance" prescribed by Fisher and Yates (1963). Comparison of treatment was made with the help of critical difference (C.D.) (Table 1–9).

Results and Discussion

Plant height (cm) and leaf area (cm^2)

The highly significant interaction effect of sowing date and plant spacing relating to plant height and leaf area was obtained. The sowing date D_2 (10 August) and transplanting at spacing of S_4 (60 × 60cm) i.e. D_2S_4 gave significantly maximum plant height (63.93cm) and leaf area (97.0cm^2), although, it was statistically comparable to treatment combinations of D_2xS_3, D_2xS_2, D_2xS_1 and D_3xS_4. The minimum plant height (44.77cm) and leaf area were noted under plants grown at the spacing of S_1 (50 × 40cm) with sowing date of D_1 (25th July) i.e.D_1xS_1.). This may be due to food accumulation was more in the plant which was grown at wider spacing. As a result the plant height and leaf area become maximum. The present results are partially agreement with results obtained by Griffith and carling (1991). Closer spacing among the plants resulted in lower plant height and leaf area due to competition of nutrients, moisture, Co_2 etc. among the roots of the plants. This might be the reason that by increasing the spacing up to a certain limit had increased the plant height and leaf area of the cauliflower plant. These results are in agreement with the findings of Rahman *et al.*, (2007). The present trend was also observed by Singh *et al.*, (1978) and Gautam *et al.*, (1998) and they reported reduced plant height in late planting. Better growth of 10th August sowing might be due to the conducive climatic conditions.

Days to 50% curd initiation

The least number of days taken to 50% curd initiation (50.67 days) was noted when seed was sown on 10th September (D_4) and transplanted at spacing of 50 × 50cm (S_2) i.e. D_4xS_2 which was statistically comparable to the treatment combinations of D_4xS_1, D_4xS_3 and D_4 x S_4. The maximum number of days taken to 50% curd initiation (80.00 days) was noted in the treatment combination of S_1xD_1.The delayed in 50% curd initiation was obtained at closer spacing (50 × 40cm). The plant transplanted at wider spacing was reached first to 50% curd initiation whereas the closer spacing significantly delayed to curd formation. This might be due to the wider spacing where plant received more nutrients, space, aeration and sunlight which causes completion of vegetative growth at faster rate and entered into reproductive phase earlier, resulted in earlier curd formation. Similar results obtained by Rahman *et al.*, (2007). This might be due to favourable conditions prevailing during the growing period when sown on 10th September. These results are in consonance with the findings of Jaiswal *et al.*, (1996).

Curd polar and equatorial diameter (cm):

Significantly maximum equatorial and polar diameter of curd (21.20cm and 10.37cm, respectively) were observed with treatment combination of D_2xS_4 i.e. seed sown on 10th August and transplanted at spacing of 60×60cm. This treatment combination was statistically comparable to the treatment combination of D2xS3, producing the curd equatorial and polar diameter of 20.63 ,cm ,respectively while the minimum were recorded in treatment combination of D1xS1.The closer plant spacing showed poor results due to close competition for acquiring the nutrients, sunlight and space for better curd growth and development. Similar results were reported by Oad *et al.*, (2002) who observed that narrow plant spacing could not record satisfactory plant characters.

Decrease in curd polar and equatorial diameter in early sown crop 25th July of sowing might be due to the poor vegetative growth, minimum storage of metabolites and higher average temperature above the requirement which resulted to the production of poor growth of the crop. Similar results were obtained by Singh *et al.,* (1997), Sharma *et al.,* (1994), Lawande *et al.,* (1991) and Gautam *et al.,* (1998).

Number of days taken to 50% flowering

The least number of days taken to 50% flowering (87days, respectively) were observed when the seeds were sown on 10^{th} September (D4) and transplanted at the spacing of 60cm x50 cm (S2) that is in treatment combination of D4xS2 which was statistically superior to all treatment combinations. The maximum number of days taken to 50% flowering (129.67 days) was observed in treatment combination of D1XS1.Similar results were quoted by Rahman *et al.,* (2007).This might be due to conducive conditions prevailing during the growing period which favoured to complete vegetative and reproductive phase earlier. Similar results were also reported by Jaiswal *et al.,* (1996).

Number of days to harvest of seed

The least number of days taken to harvest of seed (154 days, respectively) were observed when the seeds were sown on 10^{th} September (D_4) and transplanted at the spacing of 60 x 60 cm(S_4) that is in treatment combination of D_4xS_4 which was statistically superior to all treatment combinations. The maximum number of days taken to harvest of seed (189 days) was observed in treatment combination of D_1xS_3.Similar results were quoted by Rahman *et al.,* (2007).This might be due to conducive conditions prevailing during the growing period which favoured to complete vegetative and reproductive phase earlier. Similar results were also reported by Jaiswal *et al.,* (1996).

Number of inflorescence (bolters)/plant, Siliqua/plant and seed yield/plant

The different plant spacing significantly induced acceleration in number of bolters, siliqua and seed yield per plant. The highest number of bolters/plant (48.67), Siliqua/plant (1682.67) and seed yield/plant (56.33g) were recorded when plants developed under wider spacing(60×60cm) and seeds were sown on 10^{th} September. This may be due to the wider spacing where plant received more nutrients, space aeration and sunlight for better curd growth and development which increased curd size and enhanced more bolters, number of siliqua and seed yield per plant. These results are in agreement with the findings of Rahman *et al.,* (2007).

The time of sowing of seeds showed a marked variation for number of bolters, siliqua and seed yield per plant. Being a thermo sensitive plant, sowing on 10th August received comparatively low temperature during vegetative growth which produced bigger size curd which ultimately produced higher number of bolters, siliqua and seed yield per plant. These results are in consonance with the findings of Kanwar, 1996.

Number of seeds per siliqua and 1000 seed weight

Number of seeds per siliqua and 1000 seed weight influenced significantly due to the different plant spacing and date of sowing. The seed sown on 10th August and plant grown under the wider spacing (60 x 60cm) produced higher number of seeds per siliqua (21) and 1000 seed weight (3.91 g). These results are similar to the findings of Hossain *et al.,* (2015).

Table.1 Effect of sowing date and plant spacing on plant height (cm), leaf area (cm²)

Plant height (cm)					
Plant spacing (S)	Sowing date (D)				
	D_1 (25 July)	D_2 (10 Aug.)	D_3 (26 Aug.)	D_4 (10 Sept.)	MEAN
S_1(50×40 cm)	44.77	62.30	58.33	52.88	54.57
S_2(50×50 cm)	49.33	62.47	58.73	53.00	55.88
S_3(60×50 cm)	53.67	62.87	60.27	54.20	57.75
S_4(60×60 cm)	55.67	63.93	61.00	56.23	59.21
MEAN	50.86	62.89	59.58	54.08	

Leaf area (cm²)					
S_1(50×40 cm)	86.00	94.00	90.33	90.00	90.08
S_2(50×50 cm)	89.33	95.67	88.67	82.67	89.08
S_3(60×50 cm)	84.67	96.33	92.67	88.33	90.50
S_4(60×60 cm)	90.33	97.00	88.67	90.00	91.50
MEAN	87.58	95.75	90.08	87.75	

C.D. at 5%	**S**	**D**	**S×D**
Plant height	0.45	0.45	3.12
Leaf area	0.58	0.58	4.00

Table.2 Effect of sowing date and plant spacing on days to 50% curd initiation

Days to 50% curd initiation					
S_1(50×40 cm)	80.00	67.33	62.33	52.33	65.50
S_2(50×50 cm)	77.00	67.33	62.00	50.67	64.25
S_3(60×50 cm)	72.67	67.33	62.33	51.33	63.42
S_4(60×60 cm)	72.33	68.00	62.67	51.00	63.50
MEAN	75.50	67.50	62.33	51.33	

C.D. at 5%	**S**	**D**	**S×D**
Days to 50% curd initiation	0.43	0.43	2.96

Table.3 Effect of sowing date and plant spacing on curd polar diameter (cm) and curd equatorial diameter (cm)

Curd polar diameter (cm)

Plant spacing (S)	Sowing date (D)				
	D_1 (25 July)	D_2 (10 Aug.)	D_3 (26 Aug.)	D_4 (10 Sept.)	MEAN
S_1(50×40 cm)	7.50	8.80	7.83	7.67	7.95
S_2(50×50 cm)	7.53	9.73	7.97	7.87	8.28
S_3(60×50 cm)	7.80	10.00	9.10	8.40	8.83
S_4(60×60 cm)	7.93	10.37	9.50	8.97	9.19
MEAN	7.69	9.73	8.60	8.23	

Curd equatorial diameter (cm)

S_1(50×40 cm)	12.70	19.27	19.00	15.50	16.62
S_2(50×50 cm)	15.35	19.73	19.49	15.92	17.62
S_3(60×50 cm)	15.94	20.63	19.87	16.32	18.19
S_4(60×60 cm)	16.16	21.20	19.98	18.32	18.91
MEAN	15.04	20.21	19.58	16.51	

C.D. at 5%	S	D	S×D
Curd polar diameter	0.06	0.06	0.36
Curd equatorial diameter	0.14	0.14	0.97

Table.4 Effect of sowing date and plant spacing on days to 50% flowering

Plant spacing (S)	Sowing date (D)				
	D_1 (25 July)	D_2 (10 Aug.)	D_3 (26 Aug.)	D_4 (10 Sept.)	MEAN
S_1(50×40 cm)	129.67	109.67	96.33	95.67	107.83
S_2(50×50 cm)	127.33	111.33	93.67	87.00	104.83
S_3(60×50 cm)	127.33	109.00	97.33	91.67	106.33
S_4(60×60 cm)	128.00	108.67	98.33	94.00	107.25
MEAN	128.08	109.67	96.42	92.08	

C.D. at 5%	S	D	S×D
Days to 50% flowering	0.48	0.48	3.30

Table.5 Effect of sowing date and plant spacing on days to harvest of seed (bolters)/plant, Siliqua/plant and seed yield/plant

Plant spacing (S)	Sowing date (D)				
	D_1 (25 July)	D_2 (10 Aug.)	D_3 (26 Aug.)	D_4 (10 Sept.)	MEAN
S_1(50×40 cm)	187.00	175.00	163.67	156.33	170.50
S_2(50×50 cm)	188.33	172.00	164.00	158.00	170.58
S_3(60×50 cm)	189.00	172.67	165.67	158.00	171.33
S_4(60×60 cm)	187.67	176.33	162.00	154.00	170.00
MEAN	188.00	174.00	163.83	156.58	

C.D. at 5%	S	D	S×D
Days to harvest of seed	0.39	0.39	1.73

Table.6 Effect of sowing date and plant spacing on Number of inflorescence Number of bolters/plant

Plant spacing (S)	Sowing date (D)				
	D_1 (25 July)	D_2 (10 Aug.)	D_3 (26 Aug.)	D_4 (10 Sept.)	MEAN
S_1(50×40 cm)	32.00	47.00	43.33	41.00	40.83
S_2(50×50 cm)	42.67	48.00	44.00	43.00	44.42
S_3(60×50 cm)	43.00	48.33	45.67	44.67	45.42
S_4(60×60 cm)	43.33	48.67	46.67	45.00	45.92
MEAN	40.25	48.00	44.92	43.42	

Number of siliqua/plant

S_1(50×40 cm)	1259.67	1613.33	1513.00	1432.67	1454.67
S_2(50×50 cm)	1261.33	1641.67	1529.33	1452.00	1471.08
S_3(60×50 cm)	1415.33	1675.00	1554.00	1470.33	1528.67
S_4(60×60 cm)	1458.00	1682.67	1582.67	1474.33	1549.42
MEAN	1348.58	1653.17	1544.75	1457.33	

Seed yield/plant (g)

S_1(50×40 cm)	41.00	53.67	49.00	42.00	46.42
S_2(50×50 cm)	44.00	54.00	50.00	45.33	48.33
S_3(60×50 cm)	45.00	55.00	51.00	48.00	49.75
S_4(60×60 cm)	46.67	56.33	52.00	50.00	51.25
MEAN	44.17	54.75	50.50	46.33	

C.D. at 5%	S	D	S×D
Number of bolters/plant	0.41	0.41	2.81
Number of siliqua/plant	8.90	8.90	61.65
Seed yield/plant (g)	0.25	0.25	1.72

Table.7 Effect of sowing date and plant spacing on Number of seeds per siliqua and 1000 seed weight

Number of seeds per siliqua

Plant spacing (S)	Sowing date (D)				
	D_1 (25 July)	D_2 (10 Aug.)	D_3 (26 Aug.)	D_4 (10 Sept.)	MEAN
S_1(50×40 cm)	11.00	19.00	17.00	16.33	15.83
S_2(50×50 cm)	14.00	19.67	19.00	16.67	17.33
S_3(60×50 cm)	15.00	20.00	19.67	17.00	17.92
S_4(60×60 cm)	17.00	21.00	20.67	16.00	18.67
MEAN	14.25	19.92	19.08	16.50	

1000 seed weight (Test weight)

Plant spacing (S)	Sowing date (D)				
	D_1 (25 July)	D_2 (10 Aug.)	D_3 (26 Aug.)	D_4 (10 Sept.)	MEAN
S_1(50×40 cm)	2.14	3.20	2.74	2.36	2.61
S_2(50×50 cm)	2.37	3.50	3.31	2.48	2.91
S_3(60×50 cm)	2.81	3.85	3.43	2.85	3.23
S_4(60×60 cm)	2.91	3.91	3.58	3.40	3.45
MEAN	2.56	3.62	3.26	2.77	

C.D. at 5%	**S**	**D**	**S×D**
Number of Seed/siliqua	0.24	0.24	1.70
Test weight (1000seed wt.)	0.01	0.01	0.30

Table.8 Effect of sowing date and plant spacing on gross income (Rs. /ha), net income (Rs. /ha) and benefit-cost ratio

Plant spacing (S)	Sowing date (D)				
	D_1 (25 July)	D_2 (10 Aug.)	D_3 (26 Aug.)	D_4 (10 Sept.)	MEAN
S_1(50×40 cm)	6,89,000	12,29,800	9,62,000	7,28,000	9,02,200
S_2(50×50 cm)	7,54,000	12,66,200	10,06,200	7,98,200	9,56,150
S_3(60×50 cm)	7,87,800	12,74,000	10,40,000	8,65,800	9,91,900
S_4(60×60 cm)	9,36,000	13,07,800	11,25,800	10,66,000	11,08,900
MEAN	7,91,700	12,77,800	10,33,500	8,64,500	

Net income (Rs /ha)

Plant spacing (S)	Sowing date (D)				
	D_1 (25 July)	D_2 (10 Aug.)	D_3 (26 Aug.)	D_4 (10 Sept.)	MEAN
S_1(50×40 cm)	6,89,000	12,29,800	9,62,000	7,28,000	9,02,200
S_2(50×50 cm)	7,54,000	12,66,200	10,06,200	7,98,200	9,56,150
S_3(60×50 cm)	7,87,800	12,74,000	10,40,000	8,65,800	9,91,900
S_4(60×60 cm)	9,36,000	13,07,800	11,25,800	10,66,000	11,08,900
MEAN	7,91,700	12,77,800	10,33,500	8,64,500	

Table.9 Benefit: cost ratio

Plant spacing (S)	Sowing date (D)				
	D_1 (25 July)	D_2 (10 Aug.)	D_3 (26 Aug.)	D_4 (10 Sept.)	MEAN
S_1(50×40 cm)	3.02	6.18	4.62	3.25	4.25
S_2(50×50 cm)	3.40	6.39	4.88	3.66	4.58
S_3(60×50 cm)	3.60	6.44	5.07	4.06	4.79
S_4(60×60 cm)	4.47	6.64	5.57	5.23	5.48
MEAN	3.62	6.41	5.04	4.05	

These results are also in conformity with findings of Mishra (1989) and Halim *et al.*, (1995). This might be due to proper plant growth and more favourable climatic conditions prevailed during flowering and seed setting in 10th August of sowing.

Gross income (Rs /ha)

The maximum gross income (Rs.12, 77, 800) was observed on 10th August of sowing (D_2). The maximum gross income (Rs.11, 08, 900) was obtained at spacing of 60 × 60cm (S_4) which was superior to all the plant spacing. The highest gross income (Rs. 13, 07,800) was recorded in treatment combination of D_2S_4 which was superior to all the treatment combinations. The minimum gross income (Rs. 6, 89, 000) was recorded in treatment combination of D_1S_1.

The net income influenced by effect of different sowing date. The maximum net income (Rs. 10, 98, 217/ha) was recorded when plant sown on 10th August (D_2). The maximum net income (Rs. 11, 36, 67 /ha) was noted in treatment combination of D_2S_4.which was similar to the treatment combination of D_2S_3, producing the net income of Rs.1102767.00/ha.

Benefit: cost ratio

The highest benefit: cost (6.41) was recorded when plant sown on 10th August (D_2) which was superior to all sowing date. The highest benefit-cost ratio (6.64) was recorded in treatment combination of D_2S_4 which was similar to the treatment combinations of D_2S_3, D_2S_2 and D_2S_1, producing the benefit-cost ratio of 6.44, 6.39 and 6.18, respectively (Table 9).

On the basis of results and discussion made so far the present investigation the following conclusions may be drawn:-

The sowing date and plant spacing showed significant effect on growth and economics seed production of early cauliflower. The plant height, leaf area, polar diameter, equatorial diameter, number of bolters/plant, number of siliqua/plant, number of seed/siliqua, seed yield/plant, 1000 seed weight, gross income (Rs./ha), net income (Rs./ha), benefit-cost ratio were found significant when seeds were sown on 10th August and transplanted at spacing of 60 × 60cm .

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