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Effects of method of planting, spacing and transplanting dates on seed production of mid-season cauliflower (*Brassica oleracea* var. *botrytis*) under subtropical conditions of Jammu plains

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Abstract

An experiment entitled “Effects of method of planting, spacing and transplanting dates on seed production of mid-season cauliflower (*Brassica oleracea* var. *botrytis*)” was conducted at 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 two method of seed production viz., *in-situ* and *ex-situ*, three dates of transplanting viz., 10th September 2022, 20th September 2022 and 30th September 2022 and with three spacing's viz., 60 cm × 45 cm, 60 cm × 60 cm and 60 cm × 75 cm in a Split Plot Design with three replications. The study revealed that transplanting done on 20th September proved significantly superior for all seed yield characters except for days to 50% flowering and days to siliqua maturity. Among spacings, the parameters such as days to 50% flowering, days to siliqua maturity, number of siliques per plant and seed yield per plant were recorded significantly superior at 60 cm × 75 cm spacing. However, characters such as seeds per siliqua, siliqua length, seed germination percentage and seed vigour index were recorded significantly superior at a spacing of 60 cm × 60 cm. However, 1000 seed weight and seed yield per hectare (448.80 kg) were recorded significantly superior at 60 cm × 45 cm. Among different methods *in-situ* method of planting was found significantly superior with respect to most of the seed characters under study. In case of interaction, transplanting on 20th September following *in-situ* method significantly maximized seed yield per plant and seed yield per hectare.

Keywords: Cauliflower, *In-situ*, *Ex-situ*, transplanting dates, seed yield

Introduction

Cauliflower, is an important winter vegetable crop which belongs to family Brassicaceae, is cultivated in various countries all over the world including India, China, Italy, Europe, and America. It is grown for its highly suppressed ‘prefloral fleshy apical meristem’ branches called “curd”. It is a source of protein, thiamine, riboflavin, phosphorus, and potassium, as well as a rich source of dietary fibre, vitamin C, vitamin K, vitamin B6, folate, pantothenic acid, and manganese. (Bhandari and Kwak, 2015) [2]. 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. It has multiple culinary uses such as in salads, frying, and different ingredients of curry. In western countries, it is also consumed pickled. 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) [1]. Cauliflower is categorized into different maturity groups named as early group, medium group and late group. The sowing time of medium group is from August to September under subtropical condition. The demand of cauliflower seed is mostly met from mid-season varieties as there is low seed formation in early groups and no seed production in late varieties in plains.

If planting is done too early, curd may form before the commencement of chilling temperature and the plant fails to produce seeds and if temperature becomes very low before the vegetative growth is complete, the plant remains stunted, resulting in low yield of seeds. The date of

sowing is a vital non-monetary input that plays a significant role in quality seed production (Stofella and Bryan, 1998) [14]. Plant spacing is an important aspect of crop production for maximizing the yield (Rahman *et al.*, 2007) [12]. It helps to increase the number of leaves, branches and healthy foliage. Densely planted crop obstruct the proper growth and development. On the other hand, wider spacing ensures the basic requirements but decrease the total number of plants as well as total yield. Crop yield may be increased up to 25% by using optimum spacing. Hence, it is necessary to optimize proper plant spacing for obtaining higher curd and seed yield. Seed production methods also plays a key role in ensuring desired crop performance and seed yield as *in-situ* approach to seed production is more readily embraced in this crop, yet it often results in significant land wastage due to initial plant mortality and the necessity of rouging until curding stage. Conversely, *ex-situ* transplanting guarantees a more robust plant stand and minimizes land wastage. In view of this fact, the present study was undertaken with the aim of examining the optimum spacing, date of transplanting and method of seed production for obtaining higher seed yield.

Materials 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 two method of planting, three spacing and three transplanting. Total eighteen treatments viz., T₁(M₁S₁D₁), T₂(M₁S₂D₁), T₃(M₁S₃D₁), T₄(M₁S₁D₂), T₅(M₁S₂D₂), T₆(M₁S₃D₂), T₇(M₁S₁D₃), T₈(M₁S₂D₃), T₉(M₁S₃D₃), T₁₀(M₂S₁D₁), T₁₁(M₂S₂D₁), T₁₂(M₂S₃D₁), T₁₃(M₂S₁D₂), T₁₄(M₂S₂D₂), T₁₅(M₂S₃D₂), T₁₆(M₂S₁D₃), T₁₇(M₂S₂D₃), T₁₈(M₂S₃D₃) Whereas M₁= *In-situ*, M₂= *Ex-situ* and S₁ = (60 cm×45 cm), S₂ = (60 cm×60 cm), S₃ = (60 cm×75 cm) and D₁ = 10th September 2022, D₂ = 20th September 2022, D₃ = 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 days to 50% flowering, days to siliqua maturity, number of siliques per plant, number of seeds per siliqua, siliqua length, 1000-seed weight, seed yield per plant, seed yield per ha, seed germination%, seed vigour index.

Results and Discussion

Days to 50% flowering

Significant effect of method of planting, date of transplanting and spacing on days to 50% flowering of mid-season cauliflower is observed as shown in table 1. Minimum days to 50% flowering (124.44) was recorded in *in-situ* method of production (M₁). This might be due to that *ex-situ* transplanted plants require time to recover and re-establish after displacement of plants from field which led to the late flowering and hence more days to 50% flowering as compared to *in-situ*. These findings are in agreement with the earlier work of Ranjit *et al.* (2014) [13] and Bhushan *et al.* (2020) [3]. Among different dates, transplanting on 30th September resulted in minimum days of 50% flowering (124.50) as early transplanting received long cool period for growth of plant which resulted in delayed flowering. These results coincide with the findings of Castillo *et al.* (1992) [4] who reported that the short growing cycle in winter enhanced flowering. In case of spacing, higher spacing of 60 cm

× 75 cm resulted in minimum days to 50% flowering (129.66). While going through the interaction between the method of planting and date of transplanting, the minimum days (121.33) was recorded in the treatment combination M₁D₃ i.e. *in-situ* method × 30th September date of transplanting.

Table 1: Effect of spacing, date and method of planting on days to 50% flowering in mid-season cauliflower

Days to 50% flowering						
M × D						
	D ₁	D ₂	D ₃	Mean M		
M ₁	129.33	122.66	121.33	124.44		
M ₂	145.00	138.66	127.66	137.11		
Mean	137.16	130.66	124.50			
	SE(m)±	CD (0.05)				
M	0.43	2.67				
D	0.39	4.16				
M × D	0.55	1.58				
M × S						
	S ₁	S ₂	S ₃	Mean		
M ₁	125.33	124.33	123.66	124.44		
M ₂	138.66	137.00	135.66	137.11		
Mean	132.00	130.66	129.66			
	SE(m)±	CD (0.05)				
S	0.39	1.12				
M × S	0.55	NS				
D × S						
	S ₁	S ₂	S ₃	Mean		
D ₁	138.00	137.00	136.50	137.16		
D ₂	131.50	131.00	129.50	130.66		
D ₃	126.50	124.00	123.00	124.50		
Mean	132.00	130.66	129.66			
	SE(m)±	CD (0.05)				
D × S	0.67	NS				
M × D × S						
	M ₁			M ₂		
	D ₁	D ₂	D ₃	D ₁	D ₂	D ₃
S ₁	130.00	123.00	123.00	146.00	140.00	130.00
S ₂	129.00	123.00	121.00	145.00	139.00	127.00
S ₃	129.00	122.00	120.00	144.00	137.00	126.00
	SE(m)±			CD (0.05)		
M × D × S	0.95			NS		

Days to siliqua maturity

Data in Table 2 showed significant effect of date of transplanting and spacing on days to siliqua maturity. Minimum days to siliqua maturity (189.22) were recorded in *in-situ* method of seed production (M₁). This might be due to the effect of high temperature causing uniform maturity of the crop during the later state. Among different dates, transplanting on 30th September resulted in minimum day's siliqua maturity (185.16) which was statistically superior to other two dates. This may be attributed to the fact that early planting dates have improved growth and yield attributes and plants were exposed to higher temperatures at the time of maturity. Similar results were reported by Chandra and Shukla (2013) [5]. In case of spacing, plants showed significant effect on days to siliqua maturity of mid-season cauliflower. Higher spacing of 60 cm × 75 cm resulted in minimum days to siliqua maturity (189.83) which was statistically superior to other two spacing. However, interaction of method of seed production and spacing showed non-significant result.

Table 2: Effect of spacing, date and method of planting on days to siliqua maturity in mid-season cauliflower

Days to siliqua maturity						
M × D						
	D1	D2		D3		Mean
M1	195.00	189.33		183.33		189.22
M2	198.00	193.66		187.00		192.88
Mean	196.50	191.50		185.16		
	SE(m)±	CD (0.05)				
M	0.59	3.67				
D	0.22	0.64				
M × D	0.31	NS				
M × S						
	S1	S2		S3		Mean
M1	190.66	189.00		188.00		189.22
M2	194.00	193.00		191.66		192.88
Mean	192.33	191.00		189.83		
	SE(m)±	CD (0.05)				
S	0.22	0.64				
M × S	0.31	NS				
D × S						
	S1	S2		S3		Mean
D1	197.50	196.50		195.50		196.50
D2	193.00	191.50		190.00		191.50
D3	186.50	185.00		184.00		185.16
Mean	192.33	191.00		189.83		
	SE(m)±	CD (0.05)				
D × S	0.38	NS				
M × D × S						
	M1			M2		
	D1	D2	D3	D1	D2	D3
S1	196.00	191.00	185.00	199.00	195.00	188.00
S2	195.00	189.00	183.00	198.00	194.00	187.00
S3	194.00	188.00	182.00	197.00	192.00	186.00
	SE(m)±			CD (0.05)		
M × D × S	0.54			NS		

Number of siliques per plant

Data in Table 3 showed significant effect of method of planting, date of transplanting and spacing on number of siliques per plant. Maximum number of siliqua (565.07) was recorded in *in-situ* method of seed production (M₁). Among different dates, transplanting on 20th September resulted in maximum number of siliqua (568.83) which was statistically superior to other two dates. This might be due to fact that temperature during early and late transplanting may have caused reduced growth and development of seed yield contributing characters of cauliflower plants. The findings of El-Yazied *et al.* (2007) [7] are in accordance with the present study. In case of spacing, higher spacing of 60 cm × 75 cm resulted in maximum number of siliques per plant (527.38). 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 per plant. These results are in agreement with finding of Rahman *et al.* (2007) [12].

While going through the interaction between the method and dates of transplanting, the maximum number of siliqua (623.77) were recorded in the treatment combination M₁D₁ i.e. *in-situ* method × 10th September date of transplanting which was statistically superior to other interaction treatment except M₁D₂ where 615.33 number of siliques were recorded.

However, interaction between the date of transplanting and spacing, the maximum number of siliqua (603.00) were recorded

in the treatment combination D₂S₃ i.e. 20th September date of transplanting × spacing (60 cm × 75 cm). While going through the interaction between methods of seed production, spacing and date of transplanting maximum number of siliques per plant (650.00) were recorded in the treatment combination M₁D₂S₃ i.e. *in-situ* method × 20th September date of transplanting × 60 cm × 75 cm spacing.

Table 3: Effect of spacing, date and method of planting on no. of siliqua per plant in mid-season cauliflower

No. of siliqua per plant						
M × D						
	D1	D2	D3	Mean		
M1	623.77	615.33	456.11	565.07		
M2	452.00	522.33	402.11	458.81		
Mean	537.88	568.83	429.11			
	SE(m)±	CD (0.05)				
M	3.55	21.90				
D	2.86	8.24				
M × D	4.04	11.65				
M × S						
	S1	S2	S3	Mean		
M1	564.44	554.00	576.77	565.07		
M2	447.77	450.66	478.00	458.81		
Mean	506.11	502.33	527.38			
	SE(m)±	CD (0.05)				
S	2.86	8.24				
M × S	4.04	NS				
D × S						
	S1	S2	S3	Mean		
D1	505.00	553.00	555.66	537.88		
D2	542.50	561.00	603.00	568.83		
D3	470.83	393.00	423.50	429.11		
Mean	506.11	502.33	527.38			
	SE(m)±	CD (0.05)				
D × S	4.65	14.27				
M × D × S						
	M1			M2		
	D1	D2	D3	D1	D2	D3
S1	584.00	592.00	517.33	426.00	493.00	424.33
S2	646.00	604.00	412.00	460.00	518.00	374.00
S3	641.33	650.00	439.00	470.00	556.00	408.00
	SE(m)±			CD (0.05)		
M × D × S	7.00			20.18		

Siliqua Length

Data in Table 4 showed significant effect of method of planting, date of transplanting and spacing on siliqua length. Maximum siliqua length (5.79) was recorded in *in-situ* method of seed production (M₁) which was statistically higher as compared to *ex-situ* method (5.69). Among different dates, transplanting on 20th September resulted in maximum siliqua length (5.89 cm) which was statistically superior to other two dates. In case of spacing, maximum siliqua length (5.85) was recorded in S₂ (60 cm × 60 cm) However, interaction of methods of seed production, date of transplanting and spacing showed non-significant result.

While going through the interaction between the dates of transplanting and spacing, the maximum siliqua length (6.05 cm) was recorded in the treatment combination D₂S₁ i.e. 20th September date of transplanting and spacing (60 cm × 45 cm). Similar results were observed by Chandra and Shukla (2013) [5] and Ranjit *et al.* (2014) [13].

Table 4: Effect of spacing, date and method of planting on siliqua length in mid-season cauliflower

Siliqua length (cm)						
M × D						
	D1	D2	D3	Mean		
M1	5.80	5.96	5.62	5.79		
M2	5.61	5.81	5.66	5.69		
Mean	5.70	5.89	5.64			
	SE(m)±	CD (0.05)				
M	0.01	0.07				
D	0.04	0.03				
M × D	0.05	NS				
M × S						
	S1	S2	S3	Mean		
M1	5.79	5.88	5.70	5.79		
M2	5.69	5.82	5.57	5.69		
Mean	5.74	5.85	5.64			
	SE(m)±	CD (0.05)				
S	0.03	0.11				
M × S	0.05	NS				
D × S						
	S1	S2	S3	Mean		
D1	5.55	5.85	5.71	5.70		
D2	6.05	5.93	5.69	5.89		
D3	5.63	5.78	5.51	5.64		
Mean	5.74	5.85	5.64			
	SE(m)±	CD (0.05)				
D × S	0.07	0.19				
M × D × S						
	M1			M2		
	D1	D2	D3	D1	D2	D3
S1	5.66	6.10	5.61	5.43	6.00	5.65
S2	5.90	6.03	5.73	5.80	5.83	5.83
S3	5.83	5.76	5.51	5.60	5.61	5.51
	SE(m)±			CD (0.05)		
M × D × S	0.09			NS		

1000 seed weight

Data in Table 5 showed significant effect of date of transplanting and spacing on 1000 seed weight. Maximum 1000 seed weight (2.36 g) was recorded in D₂ (20th September) which was statistically superior to other two dates. In case of spacing, maximum 1000 seed weight (2.27 g) was recorded in the treatment where plants were spaced at 60 cm × 45 cm (S₁).

While going through the interaction between the dates of transplanting and spacing, the maximum 1000 seed weight (2.38 g) was recorded in the treatment combination D₂S₂ (20th September and 60 cm × 60 cm). However, interaction of methods of seed production, date of transplanting and spacing showed non-significant result. Similar results were observed by Hossain *et al.* (2015)^[8].

Table 5: Effect of spacing, date and method of planting on 1000 seed weight in mid-season cauliflower

1000 seed weight (g)				
M × D				
	D1	D2	D3	Mean
M1	2.26	2.41	2.25	2.31
M2	2.11	2.30	2.13	2.18
Mean	2.19	2.36	2.19	
	SE(m)±	CD (0.05)		
M	0.02	NS		
D	0.02	0.05		
M × D	0.03	NS		
M × S				
	S1	S2	S3	Mean
M1	2.34	2.33	2.26	2.31
M2	2.21	2.20	2.13	2.18
Mean	2.27	2.26	2.19	
	SE(m)±	CD (0.05)		
S	0.02	0.05		
M × S	0.03	NS		
D × S				
	S1	S2	S3	Mean
D1	2.32	2.22	2.02	2.19

D2	2.36	2.38	2.33	2.36		
D3	2.14	2.19	2.23	2.19		
Mean	2.27	2.27	2.19			
	SE(m)±	CD (0.05)				
D × S	0.03	0.09				
M × D × S						
	M1			M2		
	D1	D2	D3	D1	D2	D3
S1	2.40	2.42	2.20	2.25	2.31	2.08
S2	2.30	2.43	2.25	2.15	2.33	2.14
S3	2.10	2.38	2.30	1.95	2.28	2.17
	SE(m)±			CD (0.05)		
M × D × S	0.05			NS		

Seed yield per plant (g)

Data in Table 6 showed significant effect of method of planting, date of transplanting and spacing on seed yield per plant. Maximum seed yield per plant (11.38 g) were recorded in *in-situ* method of seed production (M₁). This might be due to proper growth and development and a greater number of branches per plant. Similar results were observed by Bhushan *et al.* (2020)^[3]. Among different dates, maximum seed yield per plant (11.19 g) was recorded in D₂ (20th September) which was statistically superior to other two dates. Being a thermosensitive plant, transplanting on 20th September received comparatively low temperature during growth period which produce more siliqua and seed yield per plant. These results are in line with (Kanwar, 1996)^[9] in cauliflower. In case of spacing. Maximum seed yield per plant (10.29 g) was recorded in S₃ (60 cm × 75 cm) which was statistically superior to other two spacing. This might be due

to wider spacing where plants received more nutrients, and sunlight which led to increase curd size and enhance more bolters number of siliqua and seed yield per plant. Similar results were reported by Rahman *et al.* (2007)^[12].

While going through the interaction between method of seed production and dates of transplanting, the maximum seed yield per plant (13.37 g) were recorded in the treatment combination M₁D₂ i.e. *in-situ* method × 20th September date of transplanting which was statistically superior to other interaction treatment.

When examining the interaction between the methods of seed production and spacing, the maximum seed yield per plant (12.19 g) were recorded in the treatment combination M₁S₃ i.e. *in-situ* and 60 cm × 75 cm. Maximum seed yield per plant (11.73 g) was recorded in the treatment combination D₂S₃ (20th September and 60 cm × 75 cm).

Table 6: Effect of spacing, date and method of planting on seed yield per plant in mid-season cauliflower

Seed yield per plant (g)						
M × D						
	D1	D2		D3		Mean
M1	11.87	13.37		8.90		11.38
M2	8.47	9.00		6.65		8.045
Mean	10.17	11.19		7.77		
	SE(m)±	CD(0.05)				
M	0.07	0.44				
D	0.09	0.28				
M × D	0.14	0.40				
M × S						
	S1	S2		S3		Mean
M1	10.67	11.29		12.19		11.38
M2	7.68	8.05		8.40		8.045
Mean	9.17	9.671		10.29		
	SE(m)±	CD(0.05)				
S	0.09	0.28				
M × S	0.14	0.40				
D × S						
	S1	S2		S3	Mean D	
D1	9.17	10.23		11.11	10.17	
D2	10.75	11.08		11.73	11.19	
D3	7.59	7.69		8.04	7.77	
Mean S	9.17	9.67		10.29		
	SE(m)±	CD (0.05)				
D × S	0.17	0.49				
M × D × S						
	M1			M2		
	D1	D2	D3	D1	D2	D3
S1	10.69	12.65	8.67	7.65	8.86	6.51
S2	11.92	13.17	8.76	8.54	8.99	6.62
S3	13.00	14.30	9.26	9.23	9.15	6.82
	SE(m)±			CD (0.05)		
M × D × S	0.24			NS		

Seed yield per ha

Data in Table 7 showed significant effect of method of planting, date of transplanting and spacing on seed yield per ha. Maximum seed yield per ha (437.67 kg) were recorded in *in-situ* method of seed production (M₁). Various seed yield characters such as curd size, siliqua length and number of seed per siliqua being favorable and resulted in higher seed yield. Similar findings were also reported by Mohanty and Srivastava (2002)^[11]. In case of transplanting dates, 412.73 kg was recorded in D₂ (20th September) which was statistically superior to other two dates. This may be due the fact that early transplanting dates have improved growth and yield attributes favorably. They got long cool period for proper growth resulted bigger size of head, which enhanced more branches as well as pod per plant and increased seed yield. Similar results were reported by Hossain *et al.* (2015)^[8]. Among spacing, plants showed significant effect on seed yield per ha. Maximum seed yield per ha (448.80 kg) was recorded in the treatment where plants were spaced at 60 cm × 45 cm. This might be due to closer spacing accumulates a

greater number of plants which ultimately increased seed yield. Similar results were observed by Hossain *et al.* (2015)^[8] and Chatterjee (2006)^[6].

However, interaction between method of seed production and dates of transplanting, the maximum seed yield per ha (492.70 kg) were recorded in the treatment combination M₁D₂ i.e. *in-situ* method × 20th September date of transplanting which was statistically superior to other interaction treatment. While going through the interaction between the method of seed production and spacing, the maximum seed yield per ha (526.80 kg) were recorded in the treatment combination M₁S₁ i.e. *in-situ* method × 60 cm × 45 cm (S₁) which was statistically superior to other interaction treatment. In case of interaction between date of transplanting and spacing showed significant result. Maximum seed yield per ha (503.75 kg) was recorded in the treatment combination D₂S₁ i.e. 20th September date of transplanting × (60 cm × 45 cm) which was statistically superior to other interaction treatment.

Table 7: Effect of spacing, date and method of planting on seed yield per ha in mid-season cauliflower

Seed yield per ha (kg)						
M × D						
	D1	D2		D3		Mean
M1	449.43	492.70		370.90		437.67
M2	315.21	332.77		267.41		305.13
Mean	382.32	412.73		319.15		
	SE(m)±	CD (0.05)				
M	2.11	13.03				
D	2.91	8.39				
M × D	4.11	11.86				
M × S						
	S1	S2		S3		Mean
M1	526.80	438.55		347.67		437.67
M2	370.80	307.00		237.60		305.13
Mean	448.80	372.77		292.63		
	SE(m)±	CD (0.05)				
S	2.91	8.39				
M × S	4.11	11.86				
D × S						
	S1	S2		S3		Mean
D1	448.78	388.45		309.73		382.32
D2	503.75	412.01		322.45		412.74
D3	393.86	317.86		245.73		319.15
Mean S	448.80	372.77		292.63		
	SE(m)±	CD (0.05)				
D × S	5.04	14.53				
M × D × S						
	M1			M2		
	D1	D2	D3	D1	D2	D3
S1	527.53	595.46	457.40	370.03	412.03	330.33
S2	456.16	491.00	368.50	320.73	333.03	267.23
S3	364.60	391.63	286.80	254.86	253.26	204.66
	SE(m)±			CD (0.05)		
M × D × S	7.13			NS		

Seed germination percentage

Data in Table 8 showed significant effect of date of transplanting and spacing on seed yield germination percentage. Maximum seed germination percentage (87.61%) was recorded in D₂ (20th September). This might be due to long duration and favorable climatic conditions for seed development which resulted in more viable seeds. Similar results were observed by Mohanty and Srivastava (2002)^[11], Chandra and Shukla (2013)^[5].

In case of spacing, maximum seed germination percentage (90.33%) was recorded in S₂ (60 cm × 60 cm) which was statistically superior to other two spacing. This might be due to the better development of plants at wider spacing which led to the production of healthy seeds thus increasing germination percentage. Similar results were obtained by kumari *et al.* (2019)^[10].

However, among interaction of date of transplanting and spacing showed significant result. Maximum seed germination

percentage (92.00) were recorded in the treatment combination D₂S₂ (20th September and 60 cm × 60 cm) which was statistically superior to other interaction.

Table 8: Effect of spacing, date and method of planting on seed germination percentage in mid-season cauliflower

Seed germination percentage						
M × D						
	D1	D2	D3	Mean		
M1	88.00	88.00	86.89	87.63		
M2	86.33	87.22	85.33	86.29		
Mean	87.16	87.61	86.11			
	SE(m)±	CD (0.05)				
M	0.25	NS				
D	0.36	1.03				
M × D	0.51	NS				
M × S						
	S1	S2	S3	Mean		
M1	86.22	91.66	85.00	87.63		
M2	85.55	89.00	84.33	86.29		
Mean	85.89	90.33	84.66			
	SE(m)±	CD (0.05)				
S	0.36	1.03				
M × S	0.51	NS				
D × S						
	S1	S2	S3	Mean		
D1	86.66	91.00	83.83	87.16		
D2	84.00	92.00	86.83	87.61		
D3	87.00	88.00	83.33	86.11		
Mean	85.89	90.33	84.66			
	SE(m)±	CD (0.05)				
D × S	0.62	1.80				
M × D × S						
	M1			M2		
	D1	D2	D3	D1	D2	D3
S1	87.33	84.00	87.33	86.00	84.00	86.66
S2	92.00	94.00	89.00	90.00	90.00	87.00
S3	84.66	86.00	84.33	83.00	87.66	82.33
	SE(m)±			CD (0.05)		
M × D × S	0.88			NS		

Seed vigour index

Data in Table 9 showed significant effect of method of planting, date of transplanting and spacing on seed vigour index. Maximum seed vigour index 985.06 was recorded in *in-situ* method of seed production (M₁). Among different date of transplanting, maximum seed vigour index 1026.67 was recorded in D₂ (20th September) which was statistically superior to other two dates. As cauliflower is a thermo-sensitive plant, 20th September of transplanting received comparatively low temperature during vegetative and reproductive phase as compared to other two transplanting dates which led to the production of large sized seed which ultimately enhanced the vigour index. Similar results were observed by kumari *et al.* (2019) [10]. In case of spacing, plants showed significant effect on seed vigour index. Maximum seed vigour index 982.50 was recorded in the treatment S₂ (60 cm × 60 cm).

While going through the interaction between date of transplanting and spacing, the maximum seed vigour index (1037.00) was recorded in the treatment combination D₂S₃ (20th September and 60 cm × 75 cm). However, interaction of method of seed production, spacing and date of transplanting showed significant result. Maximum seed vigour index (1057.50) was recorded in the treatment combination M₁D₂S₂ (*in-situ*, 20th September and 60 cm × 60 cm).

Table 9: Effect of spacing, date and method of planting on seed vigour index in mid-season cauliflower

Seed vigour index						
M × D						
	D1	D2	D3	Mean		
M1	967.17	1,032.50	955.50	985.06		
M2	949.16	1,020.83	918.00	962.66		
Mean	958.17	1,026.67	936.75			
	SE(m)±	CD(0.05)				
M	2.34	14.44				
D	3.85	11.11				
M × D	5.45	NS				
M × S						
	S1	S2	S3	Mean		
M1	991.18	986.00	978.00	985.06		
M2	962.00	979.00	947.00	962.66		
Mean	976.59	982.50	962.50			
	SE(m)±	CD (0.05)				
S	3.85	11.11				
M × S	5.45	NS				
D × S						
	S1	S2	S3	Mean		
D1	975.26	955.50	943.75	958.17		
D2	1,008.00	1,035.00	1,037.00	1,026.67		
D3	946.50	957.00	906.75	936.75		
Mean	976.59	982.50	962.50			
	SE(m)±	CD (0.05)				
D × S	6.68	19.25				
M × D × S						
	M1			M2		
	D1	D2	D3	D1	D2	D3
S1	982.53	1,008.00	983.00	968.00	1,008.00	910.00
S2	966.00	1,057.50	934.50	945.00	1,012.50	979.50
S3	953.00	1,032.00	949.00	934.50	1,042.00	864.50
	SE(m)±			CD (0.05)		
M × D × S	9.45			27.23		

Note: M denotes methods of seed production, M₁ = (*In-situ* method) M₂ = (*Ex-situ* method) D denotes date of transplanting, D₁= (10th September) D₂= (20th September) D₃= (30th September) S denotes Spacing, S₁= (60 cm × 45 cm) S₂= (60 cm × 60 cm) S₃= (60 cm × 75 cm)

Conclusion

For seed yield and quality parameters, *in-situ* method of seed production proved to be significantly superior as compared to the *ex-situ* whereas amongst dates of transplanting and spacing, 20th September transplanting and spacing of 60 cm × 75 cm performed better with respect to most of the seed characters under study. As far as interaction effect are concerned superior results were recorded in the treatment combination M₁D₂S₃ i.e. *in-situ* method, 20th September date of transplanting and 60 cm × 75 cm with respect to characters viz. number of siliques per plant. In case of interaction between method and date of transplanting, M₁D₂ (*In-situ* method and 20th September) significantly maximum seed yield per plant and seed yield per hectare was recorded except earliness. In case of treatment combination D₂S₃ (20th September transplanting at 60 × 75 cm spacing) significantly influenced number of siliques per plant, seed yield per plant and seed vigour index whereas number of seeds per silique, silique length and seed yield per hectare were recorded maximum in the treatment combination D₂S₁ (20th September and 60 cm × 45 cm spacing).

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Conflict of Interests

Author have declared that no competing interests exist.

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